WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

SOLICITATION, OFFER AND AWARD

CONTINUATION SHEET

THE UNDERSIGNED ACKNOWLEDGES RECEIPT OF THE FOLLOWING AMENDMENTS

TO SOLICITATION **RFP FQ16096/AMB**

Amendment Number A001 Dated 6/24/16

Amendment Number _____ Dated _____

Amendment Number _____ Dated _____

Amendment Number _____ Dated _____

Amendment Number _____ Dated _____

Amendment Number _____ Dated _____

Failure to acknowledge receipt of all amendments may render the offer unacceptable.

_____
Authorized Signature

_____
Company Name

_____
Date

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
600 Fifth Street, NW, Washington, DC 20001-2651

AMENDMENT OF SOLICITATION / MODIFICATION OF CONTRACT

1. AMENDMENT/MODIFICATION	2. EFFECTIVE DATE
A001	22 June 2016
3. ISSUED BY PURCHASING SECTION Office of Procurement and Materials Alicia M. Blanton, Contract Administrator 600 Fifth Street, NW, Room 3C-07 Washington, DC 20001	4. ADMINISTERED BY (If other than block 3)
5. CONTRACTOR NAME AND ADDRESS (Street, city, county, state, and Zip Code)	6. FORM TYPE (Check only one) X AMENDMENT OF SOLICITATION NO FQ16096/AMB DATED June 20, 2016 (see block 7)

7. THIS BLOCK APPLIES ONLY TO AMENDMENTS OF SOLICITATIONS

X The above numbered solicitation is amended as set forth in block 10. The hour and date specified for receipt of Offers ___ is extended, X is not extended. Offerors must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation, or as amended, by one of the following methods; (a) By signing and returning two copies of this amendment; (b) by acknowledging receipt of this amendment on each copy of the offer submitted; or (c) by separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGMENT TO BE RECEIVED AT THE ISSUING OFFICE PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If, by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided such telegram makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

8. ACCOUNTING AND APPROPRIATION DATA (If required)

9. THIS BLOCK APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS

(a) ☐ This Change Order is issued pursuant to _____
The Changes set forth in block 10 are made to the above numbered contract/order.

(b) ☐ The above numbered contract/order is modified to reflect the administrative changes (such as changes in paying office, appropriation data, etc.) set forth in block 10.

(c) ☐ This Supplemental Agreement is entered into pursuant to authority of _____
It modifies the above numbered contract as set forth in block 10.

10. DESCRIPTION OF AMENDMENT/MODIFICATION

A. Solicitation FQ16096/AMB is amended for the following:

1. Answers to Questions from potential suppliers. See Attachment# 1.
2. Due Date for Submittal of Proposals is extended to **July 18, 2016 at 2 p.m.**

Except as provided herein, all terms and conditions of the document referenced in block 6, as heretofore changed, remain unchanged and in full force and effect.

11. X CONTRACTOR/OFFEROR IS REQUIRED TO SIGN THIS MODIFICATION AND RETURN TWO COPIES TO ISSUING OFFICE.	☐ CONTRACTOR/OFFEROR IS NOT REQUIRED TO SIGN THIS DOCUMENT
12. NAME OF CONTRACTOR/OFFICE BY _____ (Signature of person authorized to sign)	15. WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY BY Tonia C. Nixon (Signature of Contracting Officer)
13. NAME AND TITLE OF SIGNER (Type or print)	14. DATE SIGNED
16. NAME OF CONTRACTING OFFICER (Type or print) Tonia C. Nixon	17. DATE SIGNED 6/24/16

Attachment# 1

FQ16096- Questions and Answers for Tunnel Ventilation Panels

1. Our company is interested in participating in the bid being offered by WMATA and would like the drawings and specifications.

   Answer: Please see attached Drawings, Specifications and Pictures**.**

****"The Specifications, Drawings, and Pictures are proprietary to WMATA and are provided for the sole purpose of providing information for this solicitation. The Bidder agrees not to redistribute this information and to appropriately destroy the specifications, drawings, and pictures after the solicitation closes or immediately following submission of the bid response. If the Contractor is not submitting a bid response to this solicitation, these documents must be immediately destroyed".**

END OF AMENDMENT A001

SECTION 00012

TABLE OF CONTENTS FOR DIVISIONS 2-16

END OF SECTION

SECTION 15900

ELECTRICAL CONTROL PANEL AND WIRING STANDARDS

PART 1 – GENERAL

1.1 DESCRIPTION:

A. This section specifies providing electrical and electronic control systems including complete control panels, control devices, and field components in a systems approach.

B. Related Sections:
1. Section 15901: Electrical Controls Documentation
2. Section 16145: Power Wiring and Control
3. Section 16225: Motors
4. Section 16425: Motor Starters and Control Centers

1.2 QUALITY ASSURANCE:

A. Codes, Regulations, and Reference Standards:
1. Codes and regulations of Authorities Having Jurisdiction (AHJ)
2. NEC
3. NEMA: 250, ICS-6, 12
4. IEEE: C37.90.1
5. IEEE: C62.41.2
6. ANSI: Z55.1
7. UL: 1449 Fourth Edition
8. UL: 94, 508A
9. UL: 1283
10. EIA: RS 232.C
11. ASHRAE/ANSI: 135-2001
12. ICEA: S-68-516

B. References:
1. ASHRAE 85 - Automatic Control Terminology for Heating, Ventilating, Air Conditioning.
2. ASME MC85.1 - Terminology for Automatic Control.
3. NFPA 70 - National Electrical Code 2011 edition.
4. NFPA 79 - Electrical Standards for Industrial Machinery.
5. IEC Wiring Codes for AC/DC Branch Circuits.
6. UL 508A - Industrial Control Panels.
7. UL 514B - Fittings for Conduit and Outlet Boxes.
8. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

C. Definitions:
1. Abbreviations used in this Section include the following. Additional abbreviations are indicated on the Drawings.

AGND Analog Ground

AMP	Ampere
AWG	American Wire Gauge
BL	Blue
BLK	Black
CB	Circuit Breaker
CB#X	Circuit Breaker with ID (with the “X” being replaced with a number)
COM	Common (in regards to a wire terminal common for more than one contact)
COMM	Communications
CPU	Central Processing Unit
CR	Control Relay
CR#X	Control Relay with ID (with the “X” being replaced with a number)
DIN	Component Mounting Rail
DP	Differential Pressure DPDT
	Double Pole Double
Throw	EA Each
EF	Exhaust Fan
EF#X	Exhaust Fan with ID (with the “X” being replaced with a number)
GND	Ground
GRN	Green
GRY	Gray
HMI	Human Machine Interface
HOA	Hand-Off-Auto
ID	Identification
I/O	Input and Output
ISO GND	Isolated Ground
LS	Limit Switch
LT	Light (as in LT Blue color)
mA	Milliamps
MAX	Maximum
MFR	Manufacturer
MIN	Minimum
MOV	Metal Oxide Varistors
MS	Motor Starter
MTW	Machine Tool Wire
N.C.	Normally Closed
NEG	Negative (DC Power)
NIC	Not In Contract
N.O.	Normally Open
NTS	Not To Scale
ORG	Orange
P#X	Pump with ID (with the “X” being replaced with a number)
PLC	Programmable Logic Controller
POE	Power over Ethernet
POS	Positive (DC Power)
RTD	Resistance Temperature Detector
SF	Supply Fan
SF#X	Supply Fan with ID (with the “X” being replaced with a number)
SP	Sump Pump
SPD	Surge Protection Device
SPDT	Single Pole Double Throw
SPST	Single Pole Single Throw
T	Terminal (wire)
T#X	Terminal with ID (with the “X” being replaced with a number)
TB	Terminal Block
TB#X	Terminal Block with ID (with the “X” being replaced with a number)

TCP	Transmission Control Protocol
THHN	Thermoplastic High Heat Resistant Nylon
TSP	Twisted Shielded Pair (cable)
TYP	Typical
UH	Unit Heater
UH#X	Unit Heater with ID (with the “X” being replaced with a number)
VAC	Volts Alternating Current
VDC	Volts Direct Current
VFD	Variable Frequency Drive
VIO	Violet
VU	Ventilator Unit
VU#X	Ventilator Unit with ID (with the “X” being replaced with a number)
W/	With
WMATA	Washington Area Metropolitan Transit Authority
WHT	White
YEL	Yellow
#	Number

D. Wire Color Coding Standards

1. Power wire colors

a. 480 VAC, Three Phase
   (1) Phase 1: Black with Brown Tape
   (2) Phase 2: Black with Orange Tape
   (3) Phase 3: Black with Yellow Tape
   (4) Neutral: White
   (5) Ground: Green or Green with Yellow Stripe

b. 240 VAC
   (1) Phase 1: Black
   (2) Phase 2: Red
   (3) Neutral: White
   (4) Ground: Green or Green with Yellow Stripe

2. Control wire colors

a. 120 VAC (Unfiltered Power)
   (1) Line: Black
   (2) Neutral: White
   (3) Ground: Green or Green with Yellow Stripe

b. 120 VAC (Filtered Power)
   (1) Line: Red
   (2) Neutral: White
   (3) Ground: Green or Green with Yellow Stripe

c. 24 VDC
   (1) Positive (+) Blue
   (2) Negative (-) White with Blue Stripe

d. Miscellaneous
   (1) Green or Green with Yellow Stripe will only be used for ground wires

(2) Orange is to be used for wires inside of control panels that remain energized when the respective control panel circuit is de energized. This color shall override the above color codes.
(3) Unassigned colors: Brown, Violet, and Yellow (Purposes shall be stated on drawings if used)
(4) All control and communications wiring shall be of stranded type.

1.3 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

1. Shop Drawings:

a. Submit complete drawings of each control panel that shall contain the following items:

(1) Control panel interior layout of all components and devices. All grouped items shall be identified by their unique identifiers including all items such as Terminal Blocks (ie: TB#1, TB#2, etc.). All individual components and devices shall be identified either by their actual names or device type, or shall have identifiers that correspond to a separate organizes parts list. The parts list shall be submitted on the same drawing set that the Control Panel is contained within. Control panel exterior layout shall include all switches, operators, ID placards, warning and advisory decals, and other relevant devices and components.

(2) A system layout of all field deceives, equipment, and controls that shall interface with the control panel.

(3) Wiring diagrams, in ladder logic format, and wiring schematics showing wire point to point termination shall be submitted for all internal control panel components and devices. Wire diagrams and schematics shall include remote and field device terminations, contacts, and loads.

2. Product Data Sheets:

a. Product data sheets (cut sheets) shall be submitted for approval prior to use or control panel fabrication and integration for the following types of components:

(1) Enclosures
(2) PLC's: To include bases (chassis), CPU, and communications modules, and I/O modules.
(3) Controllers
(4) Sensors, Switches, Transducers, and Transmitters
(5) Human Machine Interfaces
(6) Surge Protection Devices
(7) Communications Devices: To include gateways, convertors, and switches.
(8) Warning Devices: Audible and visual type devices.
(9) Overcurrent protection devices (circuit breakers)
(10) Other Smart or Logic based devices as the design utilizes.

3. Warranty:

a. Submit complete information concerning warranty terms and conditions including warranty period, start of warranty, and items covered.

PART 2 – PRODUCTS

2.1 PRODUCTS

1. Control components

a. Terminal blocks

(1) Terminal blocks shall be DIN rail mounted.

(2) Terminal blocks shall use screws for securing wires. No compression or binding action is permitted.

(3) Terminal blocks shall be color coded to match the above wiring color standards. Variations from the prescribed code shall be approved in writing from the WMATA mechanical engineering department.

(4) Terminal blocks shall have the ability to accept a wire with a size range of 24AWG to 10AWG per terminal space.

(5) Terminal blocks shall have a minimum electrical rating of 600V at 30 amps.

(6) Terminal blocks shall have a manufacturer provided system of being electrically connected with adjacent blocks. This system shall consist of segments of jumpers that attached to the blocks outer side (opposite DIN rail) between the screws that secures each wire termination point, per block.

(7) Each terminal block shall be labeled as described above.

(8) Chassis grounding terminal blocks (green and yellow colored) shall be mechanically fastened to the DIN rail. This creates an electrical connection between the grounding terminal block and the DIN rail.

(9) Adjacent electrically dissimilar terminal blocks shall have electrically insulating plates placed between them. This is to provide a layer of physical separation and visual identification.

(10) Terminal blocks shall be secured from shifting on the DIN rail by means of DIN rail clamping blocks. These clamping blocks shall be mounted adjacent to the end of each terminal block segment thereby securing the terminals in place.

(11) 10% spare terminal blocks shall be installed per function of panel design (ie: inputs, outputs, power, neutral, grounds).

b. Power distribution blocks

(1) Power distribution blocks shall have a transparent clear cover that prevents accidental contact with the power terminals. The clear cover allows for visual verification. The clear cover shall be removable by mechanical means.

(2) Power distribution blocks shall have sufficient terminal spaces to allow for each wire to have a dedicated terminal. No terminal shall have multiple wires unless it is designed for such a function, and it is stated on the device.

(3) Power distribution blocks may be secured to the sub panel (back plate) by threaded holes and machine screws.

c. Control relays

(1) Control relays shall be of Electro-Mechanical operation type (ie: not solid state)

(2) Control relays shall have LED indicator lights that are connected to the relays coil power for visual indication of the pilot signal presence.

(3) Control relays shall have a manual activation button that when depressed, makes the contacts change state.

(4) Control relays shall have a lever/cam that allows the relay contacts to change state in retained manual manner.

(5) Control relays shall connect (plug) into coordinating bases. These bases shall be DIN rail mounted.

(6) Control relays shall have transparent housings that allow viewing of the internal contact state for verification.

(7) Control relays shall have Metal Oxide Varistors (MOV) used on each relay coil for transient voltage spike protection.

(8) Control relays shall have one spare pole (unused) above the required quantity required per relay. This spare pole is not required to be wired up during panel building.

2. Surge Protection Devices (SPD's)

a. Modes of Protection:

(1) SPD's shall be of multiple mode operation type where protection is provided between all combinations of power, neutral, and ground conductors.

(2) SPD's shall have peak surge current capabilities of 40 kA per mode and a total of 120kA. All internal circuits shall have component level and thermal fusing.

(3) SPD's shall have their internal circuitry encapsulated in a ridged high dielectric compound to promote long life and protection from the environment and vibration.

(4) SPD's shall have visual indications for status of the devices operational capability. Status shall be displayed for both normal and for faulted statuses.

(5) SPD's shall have both Voltage and Frequency Response circuitry to protect against both impulse type and ring wave transient electrical surges.

(6) SPD's shall be warrantied for the device in full without limitation for a minimum of 25 years of service. The warranty shall include events such as lightning strikes, "Acts of god", and external factors of SPD failure. Terms of the warranty shall stipulate full device replacement as the standard corrective action upon a device or integral internal component failure.

(7) SPD's shall be used for the protection of all control circuits.

(8) SPD's shall be used for the all three phase powered devices including Soft Starts and Variable Frequency Drives (VFD) to protect the device(s) from impulse type surges and

filter out transient emissions from the device into the upstream electrical system. For multiple device control panels of like voltage, SPD consolidation is permitted if in compliance with NEC 285.12.

(9) SPD's shall have an enclosure NEMA rating of 4X minimum if installed external of control panels.

(10) Separate SPD's shall be used for each voltage within the system design.

(11) SPD's shall have upstream overcurrent protection only as recommend by the manufacturer or NEC as applicable.

(12) SPD's shall have screw terminals provided for wire termination.

(13) SPD's for use on 120VAC circuits shall have a minimum amperage capacity equal to the circuit overcurrent device size, but not less than a capacity of 15 amps.

3. Control Panel LED light fixtures

a. LED light fixtures shall emit a light color in the range of 5000 to 6000 degrees Kelvin (K).

b. LED light fixtures shall be constructed in bars of strip segments.

c. LED light fixtures used on control panel exteriors shall have a built-in switch for operational control.

d. LED light fixtures shall be powered by 120VAC power.

e. LED light Fixtures used on control panel exteriors shall have at minimum an IP67 environmental rating.

f. LED light fixtures used on control panel interiors shall have at minimum an IP20 environmental rating.

g. LED light fixtures shall have factory provided mounting holes conducive of surface mounting application.

4. Indicator Lights

a. Indicator lights shall be of size 30mm

b. Indicator lights shall be of NEMA rating 4X/12 and 13.

c. Indicator lights LED element color shall match the color of the outer visible lens.

d. Indicator lights LED element shall be field replaceable.

e. Indicator lights shall have covers that insulate their electrical connection points. This is to prevent accidental contact with door devices by persons working within the control panel.

f. Indicators lights shall meet or exceed the respective enclosures NEMA rating.

g. Indicator lights shall be secured to enclosure door by means of an anodized aluminum mounting ring, that uses a multi turn nut to secure (ie: no binding screws)

h. Indicator lights shall have the provision for testing by means of a Push to Test feature integral to the assembly unless otherwise noted on the drawing.

i. Indicator lights shall have internal contacts to allow for the push to test function. This contact shall open the Normally Closed contact before closing the Normally Open contacts.

j. Indicator lights shall have transparent extended lens (color coded caps) that are field removable.

k. All indicator lights shall have engraved legend plates that state the lights designed purpose.

5. Current Sensing Transducers

a. Transducers shall be of fixed core design that requires the wire to be sensed to be inserted into the transducer aperture rather than be hinged or split to clamp around the wire. This is to avoid rust or oxidation of any contacts on a split core type transducer.

b. Transducers shall have analog outputs with a range of 4-20ma. The transducer shall be of two wire type and loop powered.

c. Transducers shall be sized with a sensing range to allow the normal current draw of the wire to fall within the middle third of the transducers range.

6. 24VDC Power Supply (BASIS OF DESIGN: AUTOMATION DIRECT, PN: PSB24-060S-P)

a. The power supply shall be DIN rail mounted.

b. The power supply shall accept an input voltage range of 85 to 264VAC single phase or 120 to 375 VDC.

c. The power supply shall have an output of 24VDC with a trim adjustment screw on the devices front side.

d. The power supply shall have a front mounted LED status light that is illuminated green when the output voltage is normal.

e. The power supply shall have front mounted wiring terminal blocks with screw compression terminals.

f. The power supply shall have an environmental CSA rating for Class 1, division 2 hazardous locations.

g. The power supply output capacity shall be stated on the drawings.

h. The power supply shall have over voltage and overcurrent self-protection that is auto recoverable.

i. The power supply shall have an efficiency of 86% at 115VAC input.

j. The power supply shall have an output power quality of <50mVpp at 25 degrees C.

k. The power supply shall have a de rating by 2.5% at 50 degrees C, and by 4% at 70 degrees C.

l. The power supply shall be UL508 listed.

7. Warning Strobe Light (BASES OF DESIGN: FEDERAL SIGNAL, GRAINGER PN: 4A964)
    a. The strobe light shall have an impact resistant Amber colored polycarbonate lens.
    b. The strobe light shall have a field removable twist lock lens
    c. The strobe light shall have a zinc die cast body with an epoxy paint coating.
    d. The strobe light shall emit 90 flashes per minute when powered by 120VAC.
    e. The strobe light shall have an operating temperature range of -31 to 150 degrees F.
    f. The strobe light shall have a NEMA 4X and IP66 environmental rating.
    g. The strobe light shall be compatible with both 1/2" NPT and three hole surface mounting.
    h. The strobe light shall have an output intensity of 1,000,000 peak candela, and an effective candela (ECP) of 300.
    i. The strobe light shall have a lamp life of 10,000 hours.
    j. The strobe light assembly shall be 5.25 inches tall, and 4.1 inches wide when installed onto the top of an enclosure.
    k. The strobe light shall be installed waterproof as to not derate the environmental rating of the respective enclosure.
    l. The strobe light shall be UL, CUL, and CSA certified.
8. Warning Audible Beeper (BASIS OF DESIGN: MALLORY SONALERT, PN: SCE120LA2MP1B)
    a. The warning beeper shall have a nylon body
    b. The warning beeper shall mount through a 1.25 inch hole.
    c. The warning beeper shall have an external multi turn nut around the exterior body to secure the device in place.
    d. The warning beeper shall have a 2 pole removable terminal block on its rear side for wiring.
    e. The warning beeper shall emit a 2000Hz medium pulse, at five pulses per second, with an intensity of 95 dB when powered by 120VAC.
    f. The warning beeper shall be powered by 120VAC with a maximum power consumption of 40mA.
    g. The warning beeper shall have an environmental rating of 3R, 4X, and 12.
    h. The warning beeper shall be mounted on the lower side of enclosures to minimize ingress and collection of water and dirt.
9. Temperature and Relative Humidity Transmitter (BASIS OF DESIGN: E+E, PN: EE160-HT6xAPAB-Tx004M
    a. The Temp/RH sensor shall be of wall mount type.

b. The Temp/RH shall have a green and white colored polycarbonate body with an environmental rating of NEMA 4 and IP65.

c. The Temp/RH sensor shall be mounted by two screws on its external (non covered) body. The sensor shall not require the cover to be removed for surface attachment or removal.

d. The Temp/RH sensor shall have 4-20ma analog outputs coordinated with a temperature sensing range of 0 to 50 degrees C and relative humidity range of 10 to 95%

e. The Temp/RH sensor shall be loop powered by 24VAC or 24VDC.

f. The Temp/RH sensor shall have an external cover held on by four (4) captive, quarter turn screws.

g. The Temp/RH sensor shall have one printed internal circuit board that is held in place by four (4) plastic tabs. The circuit board shall have its circuitry on the underside of the board.

h. The Temp/RH sensor shall not be adjustable.

i. The Temp/RH sensor shall have a factory provided 1/2" knock out on its lower right corner and shipped with a screw in waterproof gland.

j. The Temp/RH sensor shall have a four pole screw compression terminal block.

k. The Temp/RH sensor shall be installed with waterproof cable glands where the power and signal cable enters the respective enclosure.

10. Wire Duct (BASIS OF DESIGN: AUTOMATION DIRECT, PN: T1E-1540-1)

a. Wire duct shall be white in color.

b. Wire duct shall be of thin finger design to maximize the wire penetrating slots per inch.

c. Wire duct shall have a removable snap on cover.

d. Wire duct shall be secured to substrates by screws with fender washers into tapped holes.

e. Wire duct size shall be stated on the drawings.

f. Wire duct segments shall be installed continuous and not pieced together on each section.

11. Convenience Outlet (BASIS OF DESIGN: AUTOMATION, PN: FA-REC3)

(1) Internal to enclosures

(a) The convenience outlet shall have three (3) polarized integral 5-15R type grounded receptacles rated for a combined load of 15 amps at 125VAC.

(b) The convenience outlet shall be DIN rail mounted.

(c) The convenience outlet shall have an integral terminal block with screw compression terminals.

(d) The convenience outlet shall be UL508 listed.

(e) The convenience outlet shall have upstream overcurrent protection by means of a circuit breaker. The circuit breaker shall be equal to the capacity of the convenience outlet unless stated otherwise on the drawings. The circuit breaker shall be installed adjacent to the convenience outlet.

(f) The convenience outlet shall have a maximum operating temperature of 140 degrees F.

12. Selector Switches (SEE EACH SUBSECTION BELOW FOR BASIS)

a. Body (BASIS OF DESIGN, SCHNEIDER ELECTRIC 9001 SERIES, GRAINGER PN: 5B483)

(1) The selector switch shall have a NEMA rating of 4X, 12, and 13.

(2) The selector switch shall have a non-illuminated 30MM body size.

(3) The selector switch shall have four (4) positions that are all maintained (non-spring returned)

(4) The selector switch shall have a metal bezel that is chrome in color.

(5) The selector switch shall have a cam that allows only one contact closed in each position with no duplication or overlap of contacts being closed.

(6) The selector switch shall have field replaceable contact blocks.

(7) The selector switch shall have an external multi-turn nut integral to its body.

b. Operator Interface (BASIS OF DESIGN, SCHNEIDER ELECTRIC 9001 SERIES, GRAINGER PN: 5B459)

(1) The selector switch shall have a lever style operator interface.

(2) The selector switch lever operator shall be orange in color.

(3) The selector switch lever operator shall be oversized for use with a gloved hand.

(4) The selector switch lever shall have a manufacture painted on arrow that points to a coordinated ID placard after install.

c. Contact Blocks (BASIS OF DESIGN, SCHNEIDER ELECTRIC 9001 SERIES, GRAINGER PN: 5B537)

(1) Contact blocks shall secure to the selector switch body rear side with screws.

(2) Contact blocks shall be of 30MM type.

(3) Contact blocks shall be of form “C”, SPDT contact configuration.

(4) Contact blocks shall have transparent clear bodies to allow visual inspection.

(5) Contact blocks shall have an electrical contact rating of 10amps at 250VAC.

(6) Contact blocks shall screw/clamp type wire terminals.

(7) Contact blocks shall have A600 and P600 NEMA contact ratings.

d. Identification

(1) The selector switch shall have an engraved placard that states each of the designed position functions after install.

13. RJ45 Ethernet Service Port (BASIS OF DESIGN: WOODHEAD, PN: ENSP1F5 W/ CAP PN: 67-0300)

a. The service port shall serve as an 8 wire RJ45 Ethernet jack integrated into a bulk head style fitting.

b. The service port shall have an ABS plastic body with a Viton rubber O-ring.

c. The service port shall have a female by female receptacle configuration to accept pre terminate Ethernet cables.

d. The service port shall have a screw on removable cap that is tethered to the base. The base shall have an O-ring to seal the connection between the body and cap.

e. The service port shall have an IP67.

f. The service port shall have a layer of 50 microns of gold over 100 microns of nickel for the connections at each RJ45 jack.

g. The service port shall provide a CAT5E rated communications pass-thru.

h. The service port shall be located in the lower side of enclosures to minimize the ingress of water and dirt.

i. The service port shall have an integral multi turn nut on its external body for panel attachment. The nut shall have a thread size of 1-14 UNC.

14. Miniature Circuit Breakers (BASIS OF DESIGN: EATON, AUTOMATION DIRECT, PN: FAZ-C5-1-NA-SP)

a. Circuit breakers shall have an UL489 classification.

b. Circuit breakers shall have an IEC/EN 60947-2 classification.

c. Circuit breakers shall be suitable for feeder and branch circuit device protection.

d. Circuit breakers shall be 35mm DIN rail mounted.

e. Circuit breakers shall have a voltage rating of 277VAC and 48VDC maximum.

f. Circuit breakers shall have magnetic based overcurrent protection.

g. Circuit breakers shall be capable of back feeding and HVAC applications.

h. Circuit breakers shall have a 10kA short circuit current rating.

i. The number of poles and trip setting (in amperes) shall be based on the drawings.

j. Circuit breakers shall have a “C” profile (5-10In amps in 0.1seconds) trip curve unless otherwise stated on the drawings.

k. Circuit breakers shall have a visual indicator for status where green is shown for when the circuit breaker is open, and red is shown for when the circuit breaker is closed.

l. Circuit breakers shall be compatible with field installed shunt trip and auxiliary switch installation.

m. Circuit breakers shall have IP20 rated finger safe electrical terminals.

n. Circuit breaker shall have a white nylon body with a black operator.

o. Circuit breaker size shall have a width of .7 inches per number of poles.

15. Misc. equipment mounting

a. PLCs, 24VDC power supplies, phase loss protectors, supplemental circuit breakers, etc. shall be mounted on DIN rail.

PART 3 – EXECUTION

3.1 IDENTIFICATION:

1. Control panel internal components labeling

a. Control panel components shall be identified by adhesive backed labels. The labels shall be adhered to the control panel's sub panel (back plate). Labels shall be centered to the devices width for items mounted horizontally, and centered to the left hand side for devices mounted vertically. The labels shall be machine printed with a text height of ¼ inch. The label shall be of white color with black text. The labels shall be spaced ¼ inch away from the device. The label text shall state the device ID reflected on the panel drawings. This shall include terminal blocks, circuit breakers, and devices (ie: TB#1, CB#1, Power Filter, PLC etc.) The identifiers shall match control panel drawings and electrical documentation specified within specification section 15901 (documentation for electrical control systems).

b. No control panel interior component, terminal block, circuit breaker, etc. shall receive an identifier that is duplicated either in the same enclosure or in another control panel when multiple control panels are used for the same system.

c. Terminal blocks shall be identified by a number based sequence (ie TB#1, TB#2, etc.).

2. Control panel enclosure labeling

a. Control panel exteriors shall be identified by machine engraved placards. Placards shall be fabricated to give the final appearance of black text on a white background. Placards shall be fabricated out of 1/8 inch think acrylic material. Placard size, text size, and verbiage shall be reflected on the control panel drawing. This labeling shall include system ID, indicator lights, switches, feeding power panel info placards etc.

b. Identification placards shall be affixed to control panel enclosures by stainless steel machine screws with vibration proof locknuts. The locknut shall be located on the panel interior side. The size and quantity of fasteners shall be dictated by the placard detail relevant to the control panel drawing. All penetrations made into enclosures for placard mounting shall be performed in a manner to maintain the enclosures respective NEMA rating. This may include neoprene sealing washers between the enclosure interior side and the vibration proof locknut.

c. Applicable warning and OSHA hazard identification communication labels shall be adhesive backed vinyl label(s) located on the exterior of the enclosure door. Labels to identify conditions

such as panels fed by multiple power sources, hazardous voltage, etc. Labels to be located such that no placards, lights, knobs, etc. are obscured or impacted.

3. Wire and cable labeling

   a. All wires internal to control panels shall be identified with machine printed heat shrink labels. The labels shall fully encircle the wires outer diameter for a full 360 degrees without break or seam. The labels shall be white in color with black text. The text height shall be 1/8" tall. The labels shall be installed as to allow easy viewing after installation. No wires shall receive an identifier that is duplicated either in the same enclosure, or another control panel within the system. The identifiers shall match control panel drawings and electrical documentation specified within specification section 15901 (documentation for electrical control systems).

   b. All field device wiring shall be identified with machine printed heat shrink labels. The labels shall be white in color with black text. The text height shall be 1/8" tall. The labels shall be installed as to allow easy viewing after installation. No wires shall receive an identifier that is duplicated either in the same enclosure or in another control panel when multiple control panels are used for the same system. The field wiring identifiers shall be a continuation of control panel descriptors with suffixes added as needed. The identifiers shall match control panel drawings and electrical documentation specified within specification section 15901 (documentation for electrical control systems).

   c. Wires shall be identified by a number based sequence. The wire numeric identifiers shall match the terminal block numbering, and shall match the electrical ladder diagram and schematic for the control system. No wire identifier shall be duplicated. The only for wire identification exception is wires for our legacy DTS system of monitoring and control. These wires shall receive an Alpha based convention that also reflects the DTS system (ie: DTS-A, DTS-B, etc.) to segregate them from the remaining control system.

4. Control field device labeling

   a. All field control devices shall be identified by machine engraved placards. Placards shall be fabricated to give the final appearance of black text on a white background. Placards shall be fabricated out of 1/8 inch think acrylic material. Placard size, text size, and verbiage shall be reflected on the control panel drawing. This labeling shall include components such as switches, sensors, transducers, thermostats, auxiliary control panels, junction boxes, relays, and equipment such as fans, pumps, heaters, etc. The identifiers shall match control diagrams and system documentation specified within specification section 15901 (documentation for electrical control systems).

   b. Placard attachment means: The placards shall be located and attached as follows:

      (1) Placards for control devices mounted to concrete or CMU walls, floors, and overhead (ceilings) shall be by plastic embedded anchors and stainless steel course threaded screws into the concrete.

      (2) Placards for control panels, junction boxes, and equipment electrical compartments that have hinged doors that do not allow removal shall be attached to the door of the respective panel by machine screws and vibration proof nuts.

      (3) Placards for control devices that have covers that are removable shall be attached to a flat surface adjacent to the respective device cover.

B. Control panel enclosures

   1. NEMA (Class 250) ratings and characteristics

a. Enclosures shall have a manufacturer provided NEMA rating of 4X/12 unless otherwise noted on the applicable drawings. This rating protects the electronic “smart” components housed in the enclosure from dust, dirt, contaminates, etc.

b. Enclosures shall be manufactured out of stainless steel material unless otherwise noted on applicable drawings.

c. Enclosures shall have external mounting flanges on their upper and lower sides for mounting. The flanges are to be manufacturer welded onto the enclosure body. No bolt-on mounting feet or tabs shall be approved for use. There shall be no holes or penetrations through the rear side of any enclosure.

d. Enclosures shall have hinged doors that are secured closed by a quarter turn latch assembly. On smaller sized enclosures this shall be achieved by flush quarter turn slotted latch on the exterior side. On larger enclosures the door(s) shall be secured closed by a three point latch system. The latch system shall be operated by a single quarter turn handle on the doors exterior. This handle shall have a locking provision that is factory provided. The quarter turn handle shall be made of stainless steel material.

e. Enclosures shall have designated grounding provisions for the door and shall be grounded.

f. Enclosures shall have view ports (windows) located within the door for easy viewing of internal devices where required as per the panel design. These view ports shall have a NEMA rating equal to or exceeding the rating of the enclosure.

2. Enclosure Lighting

a. Control panels shall receive interior lighting of the LED type when any of the following conditions exists in the panel design or site specific installation location:

(1) Any location where sodium vapor lighting is in used.

(2) Any tunnel location.

(3) Where the control panel is being installed within a box or outer encompassing panel board or enclosure.

(4) Any outdoor location.

(5) Inside of any control panel where the depth of the enclosure is at or exceeds twelve (12) inches deep.

b. Luminosity:

(1) Control panel interior lighting shall provide a quantity of 200 lumens output for each foot of control panel width. Any fractions of a foot shall be rounded up to the next foot increment.

c. Positioning and Control:

(1) Control panel interior lighting fixtures shall be attached by machine screws and vibration proof locknuts through the front or left and right sides of the control panel. No holes through the top of the enclosure shall be made. The light fixture shall be positioned at the top of the enclosure, near the front center, and directed downward and backwards to illuminate the panel contents while minimize blinding of any field service persons. The light fixture shall be controlled by a simple SPST switch located in a conspicuous location inside of the enclosure. The control switch shall receive an adjacent adhesive backed label stating the switch purpose. The switch may be mounted to a bracket.

3. Enclosure penetrations

   a. There shall be no penetrations through the rear or top side of any enclosure without written approval from WMATA mechanical engineering department.

   b. All penetrations into control panel enclosures, junction boxes, or field devices shall be made in a manner to maintain the respective enclosures NEMA rating. Penetrations shall be sealed by conduit sealing hubs, sealing type locknuts and bushings, neoprene sealing washers, etc.

4. Enclosure mounting

   a. The mounting or installation of any enclosure or junction box with a NEMA rating at or exceeding NEMA 3R shall be by stainless steel fasteners (type 316), concrete anchors, and Unistrut (where required).

5. Enclosure sub panels (back plates)

   a. Enclosures shall have internal removable sub panels for mounting of interior components and devices. The sub panels shall be conductive in nature. The sub panels shall mount inside of the respective enclosure by using a minimum of four (4) factory welded-on threaded studs. Flanged locknuts shall be used to secure the sub panel to the threaded mounting studs.

   b. Enclosure sub panels shall have designated grounding points and shall be grounded.

6. Control device mounting

   a. All internal control panel components and devices shall be mounted to the removable sub panel. Devices shall be mounted to segments of DIN rail. The DIN rail shall be fastened to the sub panel by means of threaded holes and machine screws, adhesive backed tape is not permitted.

7. Wire and cable termination

   a. Control and communication wiring of size 14 AWG and smaller shall have end ferrules at each termination point.

   b. Control and communication wiring that is identified as spares not landed under a terminal shall be electrically insulated at their exposed ends.

   c. Wire terminals that receive more than one wire under one terminal shall have ferrules designed for such application.

   d. All analog and Modbus cabling shall be of shielded twisted pair type. All cabling shall be grounded at a single point. The cabling shall be plenum rated unless otherwise noted on the drawings. The single point ground shall be performed at the start of each cable routing (main control logic unit) unless otherwise noted on the drawing. This is for easy location of the termination and to avoid current loops.

   e. Wire termination onto field devices equipped with screw terminals shall be by crimp-on wire terminals.

8. Wire Routing

   a. All internal control panel wiring and cabling shall be routed in wire duct when practical. Wire duct shall be fastened to the enclosures sub panel by means of threaded holes and machine

screw with washers. When wire duct is not practical, adhesive backed tie bases may be used. Tie bases shall be fastened to the sub panel by threaded holes and machine screws. No hardware is to be located on the rear side of any sub panel (back plate).

b. Spiral loom shall be used for wire and cable routing to movable objects such as any door mounted devices. The routing of such wires and cables shall be made in a manner as to prevent the door from being pulled or drifting closed from its 90 degree or greater open position. Methods of preventing the door from being pulled closed may be use of loops or wire direction changes at the point of the hinge.

c. Communications and analog cabling shall be segregated when possible from 120VAC and higher amperage conductors in order to minimize noise and signal influence.

9. Surge Protective Devices

a. Surge Protective Devices (SPD's) shall provide both Frequency Responsive Circuitry for ring wave transient removal, and Voltage Responsive Circuitry for standard protection from the larger impulses. This is to provide protection from electrical impulses in the power source and transients generated within the control panel or adjacent process.

b. SPD's for use on 120VAC and lesser systems shall be wired in series between the point of power entry point and the downstream devices.

c. SPD's shall be installed and wired up in accordance with section 285.12 of the NEC. Wire lead length shall be kept as short as possible and be limited to no longer than 12 inches on any lead. Bends in the wires shall be avoided. SPD's shall be wired into the control panel at the point where the common point of power, neutral, and grounds are grouped. This grouping shall be where all devices join electrically within the control panel. The location of SPD's shall be based off of achieving the shortest wire lead length possible, either internally or external of control panels.

d. SPD's used on the incoming power (line side) of Variable Frequency Drives shall be coordinated when power line filters are used. If power filters are installed upstream of VFD's, then SPD's for the same power feed shall be distanced to avoid interaction.

C. Control system documentation

1. Documentation for the power and control system shall be provided as identified in accordance with specification section 15901. Hardcopies of the documentation shall be laminated and installed inside of each control panel, adhered to the rear side of the door when practical. When adherence to the rear of the door is not practical, the documentation shall be installed in a permanent manner to facility wall adjacent to the control panel.

3.2 CONVENTIONS:

A. Control Design Conventions

1. Over current and branch circuit protection:

a. Circuit breakers shall be used as opposed to fuses for overcurrent protection. Electrical sourcing device sizing shall be adjusted to permit circuit breakers when possible. Use of fuses shall be approved in writing from WMATA mechanical engineering department. This is to avoid equipment outages while fuses are being obtained, and to avoid replacing the failed fuse with one of an incorrect size or type.

b. Supplementary circuit breaker protection shall be used for power feeds from control panels to field devices. This shall include both electrical loads and remote contacts. This is to protect the control system from external electric faults. These circuit breakers shall be identified and match control panel drawings and electrical documentation specified within specification section 15901 (documentation for electrical control systems).

2. Spare Input / Output (IO) allocation

a. On logic components (ie: PLC input, relay output, and analog modules) all points shall be wired from the respective module to terminals for future use. For example- on a 6 point digital input module where 4 points are needed, all 6 shall be wired between the module and the terminal block.

3. Terminal block arrangement

a. Terminal blocks shall be oriented where the terminal facing inward to the sub panel devices is considered the “panel” side, and terminals facing away from the sub panel center is considered the “field” side. These two sides shall be coordinated with spec section 15901 (documentation for electrical systems).

(1) Door mounted and cabinet exterior electrical components shall be connected to terminals on their “field” side. This allows the sub panel to be removed by only removing the “field” wiring.

b. Terminal blocks shall be arranged in segments. These segments shall have similar voltage or purpose.

(1) On control power terminal blocks, the positive and negative (on DC circuits), or the 120VAC and neutral blocks (on 120VAC circuits) shall share the same terminal block segment, and be separate segments from other blocks with different voltages or purposes with an air gap. It is desired that terminal blocks be grouped together when they have a like function. Air gaps provide both the visual indication that they are of different function, and to prevent accidental cross connection with electrically dissimilar blocks.

(2) Terminal blocks for similar purpose or function shall be grouped together.

4. Multiple level Terminal blocks

a. Terminal blocks with more than one level may be used for higher density applications where required. All levels and termination points on each terminal block shall be of the same purpose.

b. Terminal blocks with more than one level shall identify each wire termination space with a unique identifier.

5. Grouping of power terminal blocks

a. Power terminal blocks shall be grouped together as practical and located in a manner to allow SPD’s to be located with wire length as short as possible.

6. Logic I/O modules

a. Digital Outputs modules

(1) Digital output modules shall be of relay type (ie: not sinking, sourcing, or solid state types). They shall contain physical relays that change state when activated.

(2) Analog modules

(a) Analog modules shall have a resolution of 16 bits (ie: 65535 counts) per channel.

(b) Analog modules shall be of current type (ie: 0-20ma, 4-20ma)

7. Transducers, Sensors, and Transmitter shall have current based analog outputs (4-20ma type). Devices shall be two wire type (loop powered) when practical.

8. Inter-device communications:

a. Modbus RS-485 communications protocol shall be the standard for communications between control devices.

END OF SECTION

SECTION 15901

ELECTRICAL CONTROLS DOCUMENTATION

PART 1 – GENERAL

1.1 DESCRIPTION:

A. This section specifies providing electrical and electronic control system documentation including operation, diagrams, testing, and schematics for control systems. This documentation shall serve as deliverables for Operation and Maintenance needs after project completion, and shall be included in electronic and hard copy versions as the contract requires.

B. Related Sections:
1. Section 15900: Control Panel Wiring and Standards
2. Section 16145: Power Wiring and Control
3. Section 16225: Motors
4. Section 16425: Motor Starters and Control Centers

1.2 QUALITY ASSURANCE:

A. Codes, Regulations, and Reference Standards:
1. Codes and regulations of Authorities Having Jurisdiction (AHJ)
2. NEC
3. NEMA: 250, ICS-6, 12
4. IEEE: C37.90.1
5. ANSI: Z55.1
6. UL: 94, 508A
7. EIA: RS 232.C
8. ASHRAE/ANSI: 135-2001
9. ICEA: S-68-516

B. References:
1. ASHRAE 85 - Automatic Control Terminology for Heating, Ventilating, Air Conditioning.
2. ASME MC85.1 - Terminology for Automatic Control.
3. NFPA 70 - National Electrical Code 2011 edition.
4. NFPA 79 - Electrical Standards for Industrial Machinery.
5. IEC Wiring Codes for AC/DC Branch Circuits.
6. UL 508A - Industrial Control Panels.
7. UL 514B - Fittings for Conduit and Outlet Boxes.
8. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).

C. Definitions:
1. Abbreviations used in this Section include the following. Additional abbreviations are indicated on the Drawings.

AGND	Analog Ground
AMP	Ampere
AWG	American Wire Gauge
BL	Blue

BLK	Black
CB	Circuit Breaker
CB#X	Circuit Breaker with ID (with the “X” being replaced with a number)
COM	Common (in regards to a wire terminal common for more than one contact)
COMM	Communications
CR	Control Relay
CR#X	Control Relay with ID (with the “X” being replaced with a number)
DIN	Component Mounting Rail
DP	Differential Pressure
DPDT	Double Pole Double Throw
EA	Each
EF	Exhaust Fan
EF#X	Exhaust Fan with ID (with the “X” being replaced with a number)
GND	Ground
GRN	Green
GRY	Gray
HMI	Human Machine Interface
HOA	Hand-Off-Auto
ID	Identification
I/O	Input and Output
ISO GND	Isolated Ground
LS	Limit Switch
LT	Light (as in LT Blue color)
mA	Milliamps
MAX	Maximum
MFR	Manufacturer
MIN	Minimum
MOV	Metal Oxide Varistors
MS	Motor Starter
MTW	Machine Tool Wire
N.C.	Normally Closed
NEG	Negative (DC Power)
NIC	Not In Contract
N.O.	Normally Open
NTS	Not To Scale
ORG	Orange
P#X	Pump with ID (with the “X” being replaced with a number)
PLC	Programmable Logic Controller
POE	Power over Ethernet
POS	Positive (DC Power)
RTD	Resistance Temperature Detector
SF	Supply Fan
SF#X	Supply Fan with ID (with the “X” being replaced with a number)
SP	Sump Pump
SPDT	Single Pole Double Throw
SPST	Single Pole Single Throw
T	Terminal (wire)
T#X	Terminal with ID (with the “X” being replaced with a number)
TB	Terminal Block
TB#X	Terminal Block with ID (with the “X” being replaced with a number)
TCP	Transmission Control Protocol
THHN	Thermoplastic High Heat Resistant Nylon
TSP	Twisted Shielded Pair (cable)
TYP	Typical
UH	Unit Heater

UH#X	Unit Heater with ID (with the “X” being replaced with a number)
VAC	Volts Alternating Current
VDC	Volts Direct Current
VIO	Violet
VU	Ventilator Unit
VU#X	Ventilator Unit with ID (with the “X” being replaced with a number)
W/	With
WMATA	Washington Area Metropolitan Transit Authority
WHT	White
YEL	Yellow
#	Number

D. Wire Color Coding Standards

1. Power wire colors

   a. 480 VAC, Three Phase
      (1) Phase 1: Black with Brown Tape
      (2) Phase 2: Black with Orange Tape
      (3) Phase 3: Black with Yellow Tape
      (4) Neutral: White
      (5) Ground: Green or Green with Yellow Stripe

   b. 240 VAC
      (1) Phase 1: Black
      (2) Phase 2: Red
      (3) Neutral: White
      (4) Ground: Green or Green with Yellow Stripe

2. Control wire colors

   a. 120 VAC (Unfiltered Power)
      (1) Line: Black
      (2) Neutral: White
      (3) Ground: Green or Green with Yellow Stripe

   b. 120 VAC (Filtered Power)
      (1) Line: Red
      (2) Neutral: White
      (3) Ground: Green or Green with Yellow Stripe

   c. 24 VDC
      (1) Positive (+) Blue
      (2) Negative (-) White with Blue Stripe

   d. Miscellaneous
      (1) Green or Green with Yellow Stripe will only be used for ground wires
      (2) Orange is to be used for wires inside of control panels that remain energized when the respective control panel circuit is de energized. This color shall override the above color codes.
      (3) Unassigned colors: Brown, Violet, and Yellow (Purposes shall be stated on drawings if used)
      (4) All control and communications wiring shall be of stranded type.

1.3 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

1. One Line Electrical Diagrams:

a. One line electrical diagrams shall be submitted to include the following:

A. Electrical panel boards that supply power to the mechanical equipment and control system(s) to include panel board ID, location name, room number, and circuit number within the panel board.
B. Auxiliary power sources to include source ID, location name, room number, and circuit number within auxiliary the power source.
C. Disconnects / safety switches.
D. Equipment control major devices to include:
1. Power fuses
2. Circuit Breakers
3. Motor starters
4. Soft Starts and VFD's
5. Motor overloads
6. Outlets and/or attachment plugs
7. Final electrical/mechanical equipment
E. Format:
1. The one line electrical diagrams shall be in either AutoCAD 2013 compatible format, or in .PDF format printed at 11x17 inches. The 11x17 version shall be included in the O&M manuals.

2. Control diagrams to include the following:
a. Exterior and interior control panel layout overviews
A. Layout to include
1. Identification placards (system name / alpha numeric ID)
2. Warning / advisory placards
3. Component identification
a. Components to be clearly identified
b. Component naming convention must correlate to equipment as listed on equipment schedule
4. Terminal block identification (with no ID's duplicated within the system)
5. Individual terminal identification
6. Power distribution blocks
7. Designated grounding points (doors, communications, and back plates)
b. Control wiring schematic of panel interior wiring
A. Fuse type and ratings per occurrence
B. Circuit breaker type and ratings per occurrence
C. Color code legend (per WMATA mechanical engineering's requirement)
D. Abbreviation and symbols legend
c. Field device wiring to include the following:
A. Control panel termination point
B. Contact type and normal at rest state
C. Field wiring with unique identifiers
D. Device names
E. Device location if not in the same room
F. Device specific make/break settings, pressures, values, or trip points.
d. Electrical ladder type diagrams to include the following:
A. Initial point of power feed as the one line stopped at.

B. Each ladder rung numbered in sequence with unique identifier
C. Each diagram to include the upstream source through the last component on the circuit.
D. Field devices/contacts to be shown within a box and device identified.
E. Format:
1. The control diagrams shall be in either AutoCAD 2013 compatible format, or in .PDF format printed at 11x17 inches. The 11x17 version shall be included in the O&M manuals.

3. Sequence of operation:
a. The sequence of operations shall be documented to address the following aspects at minimum:
A. System power up and arrival at a normal state of readiness.
B. System power up and arrival at a catastrophic recovery state thru the state of normal readiness.
C. System operation of one complete process cycle at a normal magnitude.
D. System operation of the process cycle for alternating elements
E. System operation of the process cycle for multiple elements during increased magnitude.
F. Alarm generation and clearing process complete with tripping and resetting processes. This shall include all devices or pieces of equipment capable of alarming.
G. System shutdown to a safe state for maintenance activities.
H. Format:
1. The sequence of operations shall be submitted in paragraph, flow chart format, or a combination thereof for each described condition above. The document shall be submitted in .PDF format for approval, and shall be contained within the O&M manual as required.

4. Communications cabling to include the following:
A. DTS system interface to include the following:
1. DTS panel location (room location, room ID)
2. DTS panel termination points (terminal block and terminal #)
3. Control panel internal termination points (terminal block ID and terminal #)
4. Field devices that are wired up to the DTS, including contacts with device identification
B. Communication cable routing and termination diagram to each device (ie: PLC, HMI, gateways, converters, ect)
C. Designated shielding grounding points
D. Ethernet cable destination (room location, room number, rack, device, port, ect,
E. Format:
1. The communications diagrams shall be in either AutoCAD 2013 compatible format, or in .PDF format printed at 11x17 inches. The 11x17 version shall be included in the O&M manuals.

5. Each programmable device shall include the following:
a. Smart device programs:
A. Three (3) copies of latest program in .PDF format per device.
B. Three (3) electronic copies of latest native programs, on thumb drives, with other electronic media as required by the WMATA mechanical engineering.
1. The program shall be fully annotated to include the following:
a. Passwords or access codes
b. A description of each block and rung of logic to state the purpose.
c. Each program instruction to have a brief description
d. All logic inputs and outputs shall have coordinating addresses with the physical termination point ID on the smart device.
b. Programming software:
A. For each programmable Intelligent Electronic Device, provide configuration software, configuration file, and manuals on disks licensed to the WMATA six weeks prior to the start

of any factory acceptance tests or SCI. Provide and submit proof that the software packages are licensed to the WMATA when the software is delivered to the WMATA. Provide and submit proof that a two year software maintenance/upgrade package has been purchased for the Owner. All configuration files shall be in their native format, shall become property of WMATA, and shall not include any copyright license or any license terms that require permissions from the vendor for modifications to the files.

B. Three (3) fully licensed versions of programming software. This software shall allow for the modification, additions to, re programing of, and re installation of all programing aspects for each device. The software shall be of a manufacturer version that is the most current on the day of system commissioning.

C. Three (3) sets of any applicable communications cables, adapters, dongles, convertors, or needed proprietary devices shall be included.

1. The software license(s) or product key(s) shall be included in the chain of custody below in transfer to WMATA.

6. Chain of custody:

a. A chain of custody shall be used and maintained for all software and documentation transferred listed above within Specification Section 15901. The chain of custody shall be maintained at all times to ensure these items reach WMATA's mechanical engineering department prior to the close of the contract. The contractor shall be responsible for ensuring that the above documentation, programs, and software is conveyed to the WMATA project manager. The WMATA project manager shall ensure that the deliverables get submitted to the WMATA mechanical engineering department for review and approval.

END OF SECTION

SECTION 15902

PNEUMATIC STANDARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Pilot Duty Three-Way Solenoid Valve.
2. Pressure Gauge.
3. Pressure Relief Valve.
4. Pneumatic Filter Dryer.
5. Pressure Regulator.
6. Pneumatic tubing and fittings.
7. Pressure Transducer.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and location and size of each field connection.

PART 2 - PRODUCTS

2.01 PRODUCTS

1) Pilot Duty Three-Way Solenoid Valves (BASIS OF DESIGN: JOHNSON CONTROLS, PN: V11HAA-100
   a) Mounting:
      i) Valve shall have a manufacture provided mounting bracket onto the valve base that protrudes from one side of the valve. The protruding bracket shall have provisions for mounting to a substrate by two (2) slotted holes. The slotted holes shall have keyed slots so valve can be removed by only loosening the two mounting screws and not fully removing them.
   b) Construction:
      i) Valve shall have a die cast aluminum body.
      ii) Valve shall have a removable cover of rolled steel for access into the electrical junction cavity secured by two (2) screws.
   c) Operating Temperatures:
      i) Valve shall have a minimum operating temperature of 32 degrees F.
      ii) Valve shall have a maximum operating temperature of 140 degrees F.
   d) Pressure Rating
      i) Valve shall have a maximum operating pressure rating of 30 PSIG.
      ii) Valve shall have an operating pressure of 0 to 25 PSIG on all three ports.
   e) Electrical
      i) Valve shall accept 120VAC class power to operate.
      ii) Valve shall have a maximum power consumption of 6 watts @ 120VAC.
      iii) Valve shall have factory provided power leads that are 18 inches long.
      iv) Valve shall have a factory provided 7/8” inch hole in the valve cover for accepting conduit.
   f) Agency Listings:
      i) Valve shall be UL 429 (Electrically Operated Valves) listed, Guide YIOZ, File MH3536.
   g) Port Configuration
      i) Valve shall have three interconnected ports; one common, one normally closed, and one normally open.
      ii) All three ports shall have female 1/8 inch NPT threaded holes.
   h) Flow rate:
      i) Valve shall be capable of flowing 1.5CFM of air with a supply pressure of 15PSI thru a port open to atmosphere.

2) Pressure Gauges
   a) For Stand Alone Pipe Fitting Attachment (BASIS OF DESIGN: WIKA 232.53 SERIES, PN: 9768726)
      i) Dial Face Size
         (1) Pressure gauge shall have a dial size of 2 1/2 inches.
      ii) Connection
         (1) Pressure gauge connection shall be of lower mount type with 1/4 inch NPT external threads.
      iii) Scale
         (1) The pressure gauge range shall be sized for the normal system operating pressure to be within the middle third of the pressure gauges range.
      iv) Accuracy
         (1) The pressure gauge shall have an accuracy of 1% over the entire range.
         (2) The pressure gauge shall meet ASME B40.100 Grade 1A accuracy requirements.
      v) Construction
         (1) The pressure gauge shall have a body constructed of 316 SS.

(2) The pressure gauge shall have all wetted parts, including the process connection fitting of 316 SS.

vi) Flutter/Vibration provisions.

(1) The pressure gauge shall be of dry type with the manufacture provided ability to be filled with glycerin fluid.

b) For Pressure Regulator attachment (BASIS OF DESIGN: WIKA 232.53 SERIES, PN: 9768726)

i) Dial Face Size

(1) Pressure gauge shall have a dial size of 2 1/2 inches.

ii) Connection

(1) Pressure gauge connection shall be of back mount type with 1/4 inch NPT external threads.

iii) Scale

(1) The pressure gauge range shall be sized for the normal system operating pressure to be within the middle third of the pressure gauges range.

iv) Accuracy

(1) The pressure gauge shall have an accuracy of 1% over the entire range of the pressure gauges range.

(2) The pressure gauge shall meet ASME B40.100 Grade 1A accuracy requirements.

v) Construction

(1) The pressure gauge shall have a body constructed of 316 SS.

(2) The pressure gauge shall have all wetted parts, including the process connection fitting of 316 SS.

vi) Flutter/Vibration provisions

(1) The pressure gauge shall be of dry type with the manufacture provided ability to be filled with glycerin fluid.

3) Pressure Relief Valve

a) Construction

i) The pressure relief valve shall have a brass or bronze body.

ii) The pressure relief valve shall be of 90 degree port configuration whereas the process connection port is on the valves lower connection, and the relief port at the right hand side.

b) Connection

i) The pressure relief shall have a 1/2 inch NPT external threaded process connection.

ii) The pressure relief shall have a 1/2 inch NPT internal threaded relief vent connection.

c) Pressure rating

i) The pressure relief shall have a fixed (nonadjustable) pressure relief setting that is calibrated by the manufacturer.

ii) The pressure relief setting shall be equal to the maximum pressure of the system and devices within the pneumatic circuitry downstream.

d) Certifications

i) The pressure relief valve shall be ASME safety certified.

ii) The pressure relief valve shall have a manufacturer attached ID plate that states the ASME certification and the fixed pressure setting. This ID plate shall be of engraved type texted.

e) Manual Operation

i) The pressure relief valve shall have an external top mount pull ring for manual operation.

ii) The pressure relief valve shall allow the manual pull ring operation for routine system depressurization.

f) Disassembly

i) The pressure relief valve shall allow for field disassembly for internal cleaning and inspection.

g) BTU rating

i) The pressure relief valve shall have a BTU venting ability rating of 245,000 BTUs unless otherwise stated on the drawings.

h) Installation

i) The pressure relief valve shall be installed onto the top of the process pipe into a threaded hole, with the relief port facing to the right side, and the valves ID placard facing outward.

4) Pneumatic Filter Dryer (BASIS OF DESIGN: RTI ELIMINIZER, PN: 3P-090-P04-Fi)
   a) Construction
      i) The filter dryer shall have a powder coated aluminum main body.
      ii) The filter dryer shall have a removable polycarbonate collection bowl.
      iii) The filter dryer shall have a removable polycarbonate element tube.
   b) Connection
      i) The filter dryer shall have a 1/2 inch NPT female threaded process connection.
   c) Filter element
      i) The filter dryer shall have a field replaceable internal filter element.
      ii) The filter dryer filter element shall have a 1.0 micron filter rating.
      iii) The filter dryer filter element shall be constructed of three (3) layers of filter media consisting of stainless steel cotton re-enforced fiber and stainless steel mesh.
   d) Moisture removing
      i) The filter dryer shall remove water and moisture from the air stream.
      ii) The filter dryer shall have an automatic empting drain valve.
   e) Flow capability
      i) The filter dryer shall have a maximum CFM rate of 90 CFM at 100 PSI
      ii) The filter dryer shall have a 5 PSI maximum pressure drop across the new device at the rated CFM and PSI rating.
   f) Visual Indicator
      i) The filter dryer shall have an external visual indicator that depicts the pressure drop across the filter element.
   g) Temperature Rating
      i) The filter dryer shall have a maximum operating pressure of 125 degrees F at 150 PSI.
   h) Installation
      i) The filter dryer shall be installed into the pneumatic system with a pipe union on each side of the device to aid in replacement or disassembly.
   i) Spare Parts
      i) The filter dryer shall be provided with the following spare parts per unit supplied:
         (1) One O-ring for the connection between the main body and removable bowl.
         (2) One replacement internal filter element.
         (3) One automatic float drain assembly.

5) Pressure Regulator (BASIS OF DESIGN: NORGREN R74G SERIES, PN: R74G4AKRMG)
   a) Construction
      i) The pressure regulator shall have an aluminum body.
      ii) The pressure regulator shall have an aluminum bonnet.
      iii) The pressure regulator shall have nitrile elastomers.
      iv) The pressure regulator shall have polypropylene and TPV valve material.
   b) Connection
      i) The pressure regulator shall have 1/2 inch NPT internal threaded connections for the process inlet and outlet air ports.
      ii) The pressure regulator shall have a 1/4 inch NPT internal threaded connection for a pressure gauge. The pressure gauge shall display regulated port pressure.
   c) Maximum Operating Pressure
      i) The pressure regulator shall be capable of a maximum inlet air pressure of 300 PSIG.
   d) Operating Temperatures:
      i) Valve shall have a minimum operating temperature of -30 degrees F.
      ii) Valve shall have a maximum operating temperature of 150 degrees F.

e) Adjustment
   i) The pressure regulator shall have a top mounted fluted knob for adjusting the regulated air output pressure.
   ii) The pressure regulator shall be capable of regulating output air pressure within a range of 5 to 150 PSI.
f) Pressure Relieving
   i) The pressure regulator shall have a relieving diaphragm to exhaust air that is over the set point, or when the output pressure is adjusted downward.
g) Flow capability
   i) The pressure regulator shall have a 220 CFM flow rate.
h) Installation
   i) The pressure regulator shall be installed with pipe union fittings on each side of the device to allow for removal for repair or replacement.
i) Identification
   i) The pressure regulator shall have an identification placard affixed permanently adjacent to the regulator. The placard shall be machine fabricated with engraved text. The placard shall state the device ID and its pressure output setting. The identification placard shall be attached with screw fasteners.
j) Visual indication
   i) The pressure regulator shall have a front mounted pressure gauge as per the subsection above. The pressure gauge shall be ported into the output airport.

6) Pneumatic tubing and fittings
   a) Push to connect fittings (BASIS OF DESIGN: AUTOMATION DIRECT “NITRA” SERIES, PN: MBT14-18N)
      i) Construction
         (1) Push to connect fittings shall be constructed of molded PBT thermoplastic.
         (2) Push to connect fittings shall have internal tubing gripping rings made of stainless steel.
         (3) Push to connect fittings shall have threaded portions of nickel plated brass material with factory applied Teflon thread sealant.
         (4) Push to connect fittings shall have internal O-rings and packing for tubing connection sealing.
         (5) Push to connect fittings shall have an external color code that differentiates between inch and metric sizes.
      ii) Assembly
         (1) Push to connect fittings shall be capable of receiving Polyurethane or nylon #12 compound flexible tubing.
         (2) Push to connect elbow or tees shall allow for occasional rotation after assembly with no degradation of loss of integrity.
      iii) Disassembly
         (1) Push to connect fittings shall be capable of tool free extraction of the tubing from each fitting. Tubing shall be released by depressing a circular ring around the tubing located on the exterior of the fitting.
      iv) Operating pressures
         (1) Push to connect fittings shall have a working pressure of 150PSI
      v) Operating temperatures
         (1) Valve shall have a minimum operating temperature of 32 degrees F.
         (2) Valve shall have a maximum operating temperature of 140 degrees F.
      vi) Fitting type
         (1) Push to connect fitting type shall be represented on the drawings.
      vii) Installation
         (1) No plastic tubing push to connect fittings shall be used external of the control panel. The plastic tubing shall start at the bulkhead fittings within the control panel.

b) Flexible poly tubing(BASIS OF DESIGN: AUTOMATION DIRECT POLYURETHANE TUBING, PN: PU38BLK100)
   i) Construction
      (1) Poly tubing shall be constructed of Ester based polyurethane (PUR) 100% virgin raw materials.
      (2) Poly tubing shall be UV stabilized for outdoor installation capability.
   ii) Hardness rating
      (1) Poly tubing shall have a Shore hardness rating of A 98.
   iii) Bending radius
      (1) Poly tubing shall have the following minimum bending radiuses:
         (a) 1/8 inch OD tubing: 0.20 inches
         (b) 1/4 inch OD tubing: 0.476 inches
         (c) 3/8 inch OD tubing: 1.0 inches
         (d) 1/2 inch OD tubing: 1.102 inches
   iv) Pressure Ratings
      (1) Poly tubing shall have the following working pressure ratings at 70 degrees F:
         (a) 1/8 inch OD tubing: 240 PSI
         (b) 1/4 inch OD tubing: 180 PSI
         (c) 3/8 inch OD tubing: 150 PSI
         (d) 1/2 inch OD tubing: 150 PSI
   v) Operating Temperatures:
      (1) Valve shall have a minimum operating temperature of -40 degrees F.
      (2) Valve shall have a maximum operating temperature of 160 degrees F.
   vi) Installation
      (1) Poly tubing shall have cleanly cut deburred ends that shall be cleaned prior to assembly into the push to connect fittings to ensure the best seal.
      (2) Poly tubing shall have no sharp bends or turns that transmit stress into the push to connect fittings.
      (3) No plastic tubing push to connect fittings shall be used external of the control panel. The plastic tubing shall start at the bulkhead fittings within the control panel.
      (4) Poly tubing shall terminate with push to connect end caps in place of the system final elbow or device to allow O&M testing.
      (5) Adhesive backed ID placards shall be placed adjacent to each control panel bulkhead fitting. The placard shall state the airline purpose. See specification 15900 for additional requirements.
   vii) Color coding
      (1) Poly tubing shall be color coded as per the drawing.
c) Soft (annealed) copper tubing
   i) Construction
      (1) Alloy 122 seamless types that meet ASTM B280 requirements.
      (2) Cleaned and capped at time of purchase and storage up to the time of installation.
   ii) Size
      (1) Refer to drawing for sizes.
   iii) Installation
      (1) Soft copper shall be bent and formed by machine or hand tool and not by hand.
      (2) Soft copper installation shall be by solder type connection except connection to an air treatment device or control panel bulkhead fitting which shall be by compression type fitting.
      (3) Soft copper shall be secured by 316 stainless steel clamps, hangers, and fasteners.
d) Pipe fittings (BASIS OF DESIGN: MCMASTER, PN: 5485K24)
   i) Construction
      (1) Pipe fittings to include tees, elbows, unions, nipples, and couplings shall be of solid brass or bronze construction.
   ii) Pressure rating
      (1) Pipe fittings shall have a class 125 or 150 minimum pressure rating.
   iii) Installation

(1) Pipe nipples with an overall length of 1 1/2 inches or less shall be of hex body type to allow for fixed wrench installation or removal.
(2) Pipe unions shall have hex body type to allow for fixed wrench installation of removal.

7) Pressure Transducer (BASIS OF DESIGN: AUTOMATION DIRECT, PROSENSE SERISE, PN: PTD25-20-0100H)
   a) Construction
      i) The pressure transducer shall have 316 stainless steel housing with Viton and Santoprene elastomer seals.
      ii) The pressure transducer shall have 303 stainless steel, ceramic, and Viton wetted parts.
      iii) The pressure transducer shall have an environmental rating of IP 65.
   b) Process connection
      i) The pressure transducer shall have a 1/4 inch NPT threaded external process connection.
   c) Operating temperature
      i) The pressure transducer shall have an operating range of -13 degrees to 176 degrees F.
   d) Range
      i) The pressure transducer shall have a designed measurement range of 0PSI to 100PSI.
   e) Accuracy and Repeatability
      i) The pressure transducer shall have an accuracy of plus or minus 0.75% of full range.
      ii) The pressure transducer shall have repeatability of plus or minus 0.15% of full range.
   f) Electrical
      i) The pressure transducer shall be of 4-20ma analog output signal type.
      ii) The pressure transducer shall have an input operating voltage range of 9.6VDC to 32VDC.
      iii) The pressure transducer shall have an analog step change response time of 3ms.
      iv) The pressure transducer shall have a 12MM top mounted four pin quick disconnect cable connection. The cable shall be field removable with no tools.
      v) The pressure transducer cable shall be of shielded type construction.
   g) Certifications
      i) The pressure transducer shall have cULus E320431, CE, and RoHS ratings.
   h) Installation
      i) The pressure transducer shall have its electrical cable ran continuous, without break or extension, into the control panel final termination point.
      ii) The pressure transducer shall be mounted vertically into the top of the process to avoid water or contamination from entering its inner workings.
      iii) The pressure transducer cable shall pass through spray proof strain reliefs when the cable passes into control enclosures.
      iv) The pressure transducer cable shall be securely mounted between the transducer and the control panel. Cable runs exceeding 6 feet of cable shall be installed in RGS electrical conduit.
      v) Each pressure transducer shall receive an adhesive backed placard that states device purpose (i.e.: “UNREGULATED AIR” or “REGULATED AIR”). The placard shall be located on each end of each transducer cable.

END OF SECTION

SECTION 16060

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies work pertaining to the design and furnishing of a complete grounding and bonding system for all passenger stations, traction power stations (TPSS), tie breaker stations (TBS), and other ancillary buildings and facilities. This section includes requirements for bonding of concrete reinforcement, temporary and permanent metal piles, precast aerial segments, and locations where required and indicated on the Contract Drawings for the monitoring of stray current and corrosion control system. This section also specifies performance of electrical tests to verify that the various grounding elements meet the resistance-to-earth criteria provided within this Specification and to verify electrical continuity of the various reinforced concrete structures that contain bonded reinforcing steel.

B. Related work specified elsewhere:

1. Section 02415: Earth Tunneling
2. Section 02416: Earth (EPBM) Tunneling
3. Section 02417: NATM Excavation
4. Section 02820: Fencing
5. Section 03200: Concrete reinforcement
6. Section 15205: Piping systems
7. Section 16120: Wire, Cable and Busways
8. Section 16710: Communications Grounding
9. Section 16922: ATC – Lightning/Surge Protection and Grounding Systems
10. Design Drawing: DD-E-077; DD-E-078; DD-E-090; DD-E-103

1.2 QUALITY ASSURANCE

A. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of the Authority Having Jurisdiction (AHJ).
2. NACE International SP0169-2007
3. National Electrical Code (NEC), latest edition.
4. ANSI/IEEE 80-2000, IEEE Guide for Safety in AC Substation Grounding.
5. ANSI/IEEE 81-2012, IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System Part 1: Normal Measurements.
6. UL 467 Revisions 10, UL Standard for Safety Grounding and Bonding Equipment.
7. American Society for Testing and Materials (ASTM) B 187-00, Standard Specification for Copper Bar, Bus Bar, Rod and Shapes.
8. ITS: Directory of ITS Listed Products.
9. National Fire Protection Association (NFPA) 130, latest edition.

B. Source Quality Control:

1. Each item, except for traction power components and exothermically welded electrical connections, listed per referenced UL or ITS directory.

C. Quality Control Testing

1. The tests are to be performed by a company regularly engaged in the field of electrical and corrosion control testing. The Contractor shall submit a test plan to the Authority for review and approval prior to testing. Assigned personnel to the project are to be familiar with stray current corrosion control electrical testing procedures, electrical instrumentation and general electrical networks. Personnel must be capable of modifying the procedures specified in the test plan to suit actual field conditions should such modifications become necessary. Any modification to the test plan shall be submitted to the Authority for review and approval.

2. The number of readings taken to determine an electrical constant or property must be sufficient to assure that random factors due to human error in reading the instruments and transient disturbances in the electrical network have negligible influence on the final results. The adequacy of the data shall be established by the Authority. The data shall be examined by the Contractor to see that removal of either the highest or lowest value will not alter the arithmetic average of the group by more than five percent. If the average is altered by more than five percent, one more set of data shall be taken and the results combined with the first set. If the average of the combined data is still altered by more than five percent, by removal of the highest or lowest value, an unstable condition might exist, and the Authority shall be advised.

1.3 SUBMITTALS

1. Submit the following for approval in accordance with the Contract Documents and with the additional requirements specified in Shop Drawings.

2. Test Plan: The test plan shall include, at a minimum, testing procedures, testing agency's name and qualifications, test personnel's' names and qualifications, equipment lists, calibration certificates, test personnel's' resumes and certifications, and standard data sheets for each test.

3. Test Report: The test report shall be certified and shall include, at a minimum, the following:

   a. Narrative of the testing performed and a summary of the results.

   b. A description of approved modifications to test procedures.

   c. All completed test data forms for grounding system tests, pre-pour inspections/tests, post-pour tests, and verification tests of electrical continuity.

   d. All calculations performed to evaluate compliance with the specifications.

   e. A listing of all deficiencies. The list shall include a description of the deficiency identified, the structure location, the corrections completed, and the retest data demonstrating compliance with the specifications.

   f. Layout drawings of systems being tested, showing location of system components, including test stations.

   g. Instrument hook-up for each test.

h. Certifications of compliance verifying that resistance of each ground grid when installed and each ground bus when connected to ground grid does not exceed specified values.

i. Certifications of compliance with the specifications for each structure tested that includes bonded reinforcing steel or verification of electrical continuity.

j. Equipment calibration certificates for all test equipment utilized.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Mark each item in accordance with applicable reference standard.

B. Ship each unit securely packaged and labeled for safe handling and to avoid damage.

C. Store equipment as recommended by the equipment manufacturer or in a secure and dry storage facility.

PART 2 - PRODUCTS

2.1 PRODUCTS AND MATERIALS

A. Grounding and Bonding Equipment:

1. General Requirements:

a. UL 467.

2. Ground rods: 5/8" or larger mild steel, with stainless steel or copper jacket by 10 feet long or of necessary length in 10-foot sections as required.

3. Grounding conductor:

a. Grounding electrode conductors:

1) Insulated or bare conductor, as shown or as required, in accordance with the following:

a) Insulated conductor: As specified in Section 16120 or Section 16128.

b) Bare conductor: As specified in Section 16120 or Section 16128.

2) Size:

a) For use in ground grid and for connecting of ground grid to ground bus: 4/0 AWG.

b) For connection of ground bus in train-control, communications, electrical, dispatcher, Telephone system and mechanical rooms to main ground bus in ac-switchboard rooms or TPSS/TBS: 2/0 AWG.

c) For other grounding electrode conductors: In accordance with NEC Table 250-66.

d) For connection of TPSS/TBS enclosures to ground grid: 4/0 AWG.

b. Equipment grounding conductor:

1) Sized in accordance with NEC Article 250-122 unless otherwise shown.

2) Insulated or bare equipment grounding conductor: Single-conductor or multi-conductor cable as specified in Section 16120 or Section 16128, as applicable.

c. Bonding conductor for stray current control, cathodic protection and electrical continuity: Insulated or bare conductors, size as required or specified:

4. Bus bar: ASTM B187-00, 98-percent-conductivity copper bus bar, size two-inches wide by 1/4-inch thick, length as necessary.

5. Terminal lugs:

a. For 4/0 AWG and smaller conductors: Copper compression terminal lugs.

b. For 250 kc mil and larger: Long-barrel, copper, double- compression terminal lugs.

6. Ground connector:

a. O-Z, Type KG or equal.

b. Two-piece, designed for connecting grounding conductor to bus bar.

c. Copper-alloy body and silicon-bronze bolt nut and lock washer with interlocking clamp.

7. Jumpers: Copper braided or leaf-type flexible jumper, size as necessary.

8. Bus-bar insulators: Fiberglass reinforced-polyester insulator with ½-inch diameter threaded holes at both ends for bus-bar installation.

a. Insulators shall have a minimum voltage rating of 600 volts.

9. Exothermic welded electrical connections:

a. Exothermic process using powdered metals contained in a mold to form a molecular bond between materials to be connected without application of an external source of heat or power in accordance with ANSI/IEEE 80-2000.

b. Molds, weld metal and associated accessories designed for making electrical connections between copper and copper, copper and steel, copper and cast iron and copper and ductile iron as required.

c. Connections made outdoors for grounding using the standard process and not containing phosphorous or any caustic, toxic or explosive materials.

d. Connections made indoors or in confined spaces for grounding using a low-smoke, low-emission process and/or proper ventilation complying with safety standards.

e. Connections made specifically for cathodic protection applications using the standard process as specified.

f. Molds made of graphite with permanent marking indicating name of manufacturer, model, conductor size, and type and size of welding

mixture compatible with the welding process. Mold connection type suitable for making connections between various configurations of items as shown or specified.

g. Weld metal consisting of copper oxide and aluminum contained in a moisture-resistant container along with other necessary materials required for the specific application other than low-smoke, low-emission process to also include suitable starting material.

h. Container for weld metal identified with part number, type of metals to be connected and application such as standard outdoor, low- emission or cathodic application.

10. Bonding Straps for Reinforced Concrete Structures:

a. Mild steel ½" inch thick by 2 inches wide by length required to span gap between transverse rebar in top and bottom rebar layers in deck or invert and/or between transverse rebar in inner and outer rebar layers in walls/abutments.

11. Test Stations for Reinforced Concrete Structures:

a. Embedded Test Box: Cast Iron Alloy, suitable for flush-wall in concrete structure, sized as shown on the Contract Drawings, complete with a weather tight neoprene gasket with the following additional requirements:

1) Threaded outlet(s) for conduit entry

2) Cover Logo to read "WMATA CORROSION CONTROL"

b. Surface Mounted Test Box: Galvanized steel box with conduit knockouts for conduit hubs. See contract drawings for size. Complete with a weather tight neoprene gasket. Box to have cover label "WMATA CORROSION CONTROL".

c. Embedded Test Station for Cast-in Place Track Slab:

1) Tube: ABS plastic.

2) Lid: Cast iron locking lid, Yellow with permanent marking "WMATA CP Test" to withstand AASHTO H-20 traffic loads

d. Terminal Block: Phenolic resin, plastic, Micarta, Lexan, or Bakelite high dielectric material, with minimum of 2 terminals, unless otherwise shown on Drawings. Terminals: Nickel plated brass 1/4 inch threaded studs, nuts, and washers. Copper buss bars shall be dimensioned as shown on the drawings

e. Approved Manufacturers:

1. Cooper/Crouse-Hinds Series WEB Junction Box or approved equal.
2. Hoffman ASG Style or approved equal.
3. Bingham and Taylor or approved equal.

PART 3 - EXECUTION

3.1 GROUNDING

A. Ground Connections:

1. Weld buried ground connections exothermically, in accordance with manufacturer's recommendations. Clean and coat with coal-tar epoxy before backfilling. Encapsulate buried ground connection of grounding electrode conductors running to ground bus with epoxy resin.

2. Use terminal lug to connect grounding conductor to equipment enclosure. Use ground connector to connect grounding conductor to ground bus. Secure connector or terminal lug to the conductor so as to engage all strands equally. Install terminal lug using tools and pressure recommended by the manufacturer. Indent mark terminal lug with the number of die used for installation.

3. Exothermically weld connections to ground rods in hand holes, junction boxes and manholes, frame columns of bus passenger and bus supervisor shelters and station entrance pylon (Type B) and light poles.

4. Splices in grounding conductor are prohibited.

5. For making ground connections located indoors and in confined spaces located outdoors such as manholes, use exothermic welds with low-smoke, low-emission process.

B. Ground Grid:

1. Install ground grid consisting of grounding conductors and ground rods buried in earth in rectangular pattern (preferred) or as shown.

2. Use 5/8” or larger ground rods 10 feet long or of greater length in 10-foot sections as shown or as required.

3. Bury top of ground rod 24 inches minimum below unfinished surfaces.

4. Ensure 24-inch minimum separation between ground rods or bare grounding conductors and concrete structures or soldier piles bonded for stray current and cathodic protection.

5. Interconnect ground rods using 4/0 AWG insulated or bare grounding conductor as shown or as required.

6. For connecting ground grid to ground bus in associated traction power substation, dc tie breaker station and ac-switchboard room, provide minimum of four 4/0 AWG insulated grounding electrode conductors. Install conductors in conduit where protection is needed.

7. For connecting ground grid to ground bus in dc tie-breaker station, provide two 4/0 AWG insulated grounding electrode connections.

8. For grounding of pad-mounted transformers or rectifier-transformer in outdoor location, provide one insulated grounding electrode conductor from nearest ground grid to transformer ground pad in addition to one insulated grounding electrode conductor from ground bus in TPSS to transformer ground pad.

9. Unless otherwise shown, leave pigtail, 3’- 6” minimum length, above finished floor for connection to ground bus or service-entrance equipment.

10. When ground grid is provided for electrical room, connect ground grid to ground bus in electrical room with two 4/0 AWG insulated grounding

electrode conductors.

C. Ground Bus:

1. Install ground bus bar, two-inches wide by 1/4-inch thick, around the inside periphery of traction-power substation, dc tie-breaker station, passenger stations ac-switchboard room, electrical rooms and all other medium voltage electrical vault rooms. In motor controls and mechanical rooms install bus bar on full length of wall adjacent to service equipment.

2. Install and label Facility ground bus bar, two-inches wide by 1/4-inch thick by 24 inches long in train-control, communications, dispatcher, telephone system and mechanical rooms and where shown. Install and label Facility ground bus bar, two-inches wide by 1/4-inch thick by 12 inches long in kiosk and escalator pits and where shown.

3. Mount ground bus bar on insulators two-feet above finished floor, unless otherwise shown, using cap screws and expandable threaded anchor.

4. Provide insulator support at each end of ground bus and at three-foot intervals.

5. In traction-power substation, dc tie-breaker station, ac-switchboard room, connect the ground bus to 4/0 AWG grounding conductor running from associated ground grid.

6. In train-control, communications, electrical, dispatcher telephone system and mechanical rooms, escalator pits, elevator rooms, battery rooms and other locations shown, connect ground sub-buses directly to main ground bus in associated ac-switchboard room, traction- power substation or dc tie-breaker station, using 2/0 AWG insulated grounding conductor.

7. Install 4/0 AWG insulated grounding conductor, sub-ground bus, with one end connected to ground bus in ac-switchboard room, at following locations:

   a. In each cable trough along mainline track, install grounding conductor.

   b. In each cable space under station platform, install grounding conductor on channel inserts on wall.

8. Installing grounding connections in train-control and communication rooms:

   a. Install and label Equipment ground bus bar, two inches by 1/4-inch by 24 inches long. This Equipment ground bus bar shall be directly connected to the AC room grounding bus using 2/0 AWG insulated grounding electrode conductor in dedicated conduit. The insulated grounding electrode conductor shall be labeled at both ends. Do not bond equipment or metallic structure to this ground bus.

   b. Install and label Facility ground bus bar, two inches by 1/4-inch by 24 inches long. This Facility ground bus bar shall be directly connected to the AC room grounding bus using 2/0 AWG insulated grounding electrode conductor in dedicated conduit. The insulated grounding electrode conductor shall be labeled at both ends.

   c. The ground connection from the AC switchboard room and TPSS/TBS to the Equipment ground bus in the train-control and communication rooms shall be a direct connection with no other connections other than the respective equipment ground connections.

d. For non-equipment items requiring bonding, have the bonding conductors connected to the Facility ground bus.

D. Equipment Grounding Conductor: Provide insulated equipment grounding conductor for following services and as required:

1. Feeders.

2. Branch circuits.

E. Grounding of Service Equipment:

1. Ground in accordance with NEC.

2. Ground enclosure and ground bus in switchgear, switchboard, motor-control center or panelboard to ground bus provided in substation or room using insulated grounding conductor.

3. Install copper bonding jumper between neutral and ground bus as shown on standard design drawing.

F. Grounding of Separately Derived AC System:

1. Ground in accordance with NEC.

2. Ground secondary neutral and enclosure of transformers to nearest ground bus or sub-bus using insulated grounding conductor.

3. For transformer located outside of building, install additional grounding conductor between transformer secondary neutral/enclosure and ground bus or grid using insulated grounding conductor.

4. For pad-mounted transformers, install and connect four ground rods around the transformer as shown on standard design drawing.

G. Grounding for Personnel Safety:

1. In substation, electrical and mechanical rooms, tie-breaker stations, chiller plants, bond exposed metallic structures, motor frame, ac-equipment enclosure, ductwork and metallic piping to local ground bus, using minimum of 6 AWG insulated grounding conductor as follows:

a. Ground multiple items of exposed metallic structure to local ground bus using a separate grounding conductor for each item or by using series-connected grounding conductors to connect two or more items.

b. Ground each ac equipment enclosure to local ground bus using a separate grounding conductor.

c. Connection of grounding conductor for ac equipment enclosure in series with grounding conductor for exposed metal structure is prohibited.

2. Bond escalator and elevator motor frames, ac-equipment enclosures and metallic structures to equipment grounding conductor in ac-power feeder and to local ground bus bar. Provide a second ground path, connecting trusses and guide rails, using a 1/0 AWG insulated ground conductor connected to ground bus bar in ac switchboard room. Leave 20-foot length of conductor coiled up in pits or well way for making grounding connections to trusses and guide rails of the escalators.

3. Bond metallic ladders and stairs to local ground bus, using insulated

grounding conductor, 6 AWG minimum.

4. Bond and ground exposed metallic structures in open areas to separate grounding electrode to meet the grounding resistance criteria in Section 3.3B of these specifications and the National Electrical Code, buried with top 2 feet below grade with two-foot separation from footing, using insulated grounding conductors in accordance with the following requirements:

   a. Metal pole for mounting light fixtures: Bond and ground using 6 AWG insulated grounding conductor.

   b. Metallic cable troughs alongside track: Bond and ground cable troughs at approximately 50-foot intervals and at each end, using 4 AWG insulated grounding conductor. At expansion and contraction joints, install flexible 4 AWG insulated grounding conductor for electrical continuity. The above does not apply to epoxy-concrete type cable trough manufactured by Plastibeton "or equal".

   c. Metallic railings and fences alongside track: Bond and ground railings and posts for galvanized steel fence at approximate 50-foot intervals and at each end, with 2-foot separation from railing and fence-post footing and other reinforced structure, using 4 AWG insulated grounding conductor. For electrical continuity, where necessary, install flexible copper braided or leaf-type jumper or 4 AWG insulated grounding conductor. In addition to the above requirements for grounding galvanized steel fences. Provide the following for grounding PVC-coated steel fences:

      1) Bond and ground each fence post to bottom tension wire using 6 AWG bare grounding conductor, O-Z Type CG, Burndy Type GAR or equal connector at fence post, and Burndy Type KS or equal tap connector at tension wire.

      2) At connections of grounding conductors to posts and tension wires, remove vinyl coating at contact surfaces before making connections and apply vinyl coating over finished connections to match original coating.

   d. Railing, cable trough and metallic-deck structure at aerial track:

      1) At each abutment and pier, install 4/0 AWG insulated grounding conductor buried 2' below grade with one end connected to 5/8" or larger, 10-foot long ground rod(s) as required to meet the grounding resistance and three-foot pigtail on the top of abutment for bonding and grounding of deck structure.

      2) Bond and ground deck structure, cable trough and hand railing to 4/0 AWG insulated grounding conductor installed at each abutment using 4 AWG insulated grounding conductor. For providing electrical continuity, where necessary, install flexible copper braided or leaf-type jumper or 4 AWG insulated grounding conductor.

5. In underground locations, bond and ground hand railing and metallic safety walk grating at each end and at approximately 50-foot intervals to nearest ground bus or sub-bus, using 6 AWG insulated grounding conductor. For electrical continuity, where necessary, install flexible copper braided or leaf-type jumper or 6 AWG insulated grounding conductor. In public areas where a person can make contact simultaneously with the hand rail and rail car, insulating epoxy paint shall be used on the hand rail.

6. Site Windscreens, bus passenger and supervisor shelters equipped with light fixtures: Provide multiple ground paths as follows:

   a. Bond and ground two separate frame columns of each single or double windscreens, passenger or supervisor shelter to two separate ground rods using 6 AWG insulated grounding conductor. Drive ground rod with top of rod six inches below finished grade.
   b. Bond and ground each shelter to equipment grounding conductor in branch circuit.

7. Windscreens and passenger shelters equipped with illuminated diorama and receptacle at station platform: Provide multiple ground paths as follows:

   a. Bond and ground two separate frame columns of each windscreen or shelter to nearest ground bus in electrical room or sub-bus or to 5/8" or larger 10-foot long ground rod driven so that the top of rod is three-inches above finished floor of under platform space using 6 AWG insulated grounding conductor unless otherwise shown.

   b. Bond and ground each windscreen or shelter to equipment grounding conductor in branch circuit.

8. Illuminated diorama, station pylon equipped with light fixtures, map case and telephone enclosure: Provide multiple ground paths as follows:

   a. Bond and ground illuminated diorama frame, column of station pylon equipped with light fixtures, map case and telephone enclosure to nearest ground bus in electrical room or sub-bus or to 5/8" or larger 10-foot long ground rod driven so that the top of rod is three-inches above finished floor of under platform space using 6 AWG insulated grounding conductor unless otherwise shown.

   b. Bond and ground frame of each illuminated diorama, pylon equipped with light fixture, map case and telephone enclosure to equipment grounding conductor in branch circuit.

9. Station entrance pylon (Type B): Provide multiple ground paths as follows:

   a. Bond and ground the pylon frame using 6 AWG insulated grounding conductor to 5/8" or larger 10-foot long ground rod driven so that top of rod is six-inches below finished grade.

   b. Bond and ground the pylon frame to equipment grounding conductor in branch circuit.

10. Handhold, manhole and junction box metallic body, cover frame and cover: Provide a minimum of two ground paths as follows:

    a. Bond and ground hand hole, manhole and junction box metallic cover frame and metallic body to 5/8" or larger 10-foot long ground rod driven with top of rod three-inches above bottom of manhole, hand hole and junction box using 6 AWG insulated grounding conductor.

    b. Provide a minimum of 6 AWG insulated grounding conductor and a bronze or brass chain with 210-pound breaking strength in a 1/2-inch or 5/8-inch rubber hose to bond metallic cover to metallic cover frame. Length of cable, chain and hose as required allowing removal of cover adjacent to and clearing of hand hole and/or manhole opening.

    c. When cable is spliced in hand hole, manhole or junction box, bond metallic cover frame and body to equipment grounding conductor.

11. Exothermically weld or braze grounding and bonding connection to exposed

metallic structure, metallic cable trough, galvanized steel fence, hand railing, metallic safety walk grating, map case and telephone enclosure, frame columns of shelter, pylon and diorama, and metallic cover, metallic cover frame and metallic body of hand hole, manhole and junction box. Repair damaged galvanized coating in accordance with Section 02820. Repair finish of shelter, map case and telephone enclosure and diorama frame to match existing finish.

12. Fire protection pipe shall be bonded in accordance with Section 01526. Bonded fire protection pipe joints shall be tested for electrical continuity as described in Section 13115.

3.2 BONDING FOR STRAY CURRENT AND CATHODIC PROTECTION

A. Reinforcing Steel in Tunnel, At-Grade and Aerial Sections:

1. Bond reinforcing steel, using 250 kcmil, Class G, stranded bare conductor exothermically welded to steel straps as shown, in accordance with Section 03200.

2. Bond reinforcing steel in pre-cast and cast decks and girders, in retaining walls and in abutments as shown on the Contract Drawings and in accordance with Section 03200.

3. Coordinate bonding in precast structures with the concrete casing company to ensure all reinforcing steel and post tensioning ducts and other internal elements are bonded in accordance with the Contract Documents.

B. Floating-Slab Expansion Joints:

1. Bond floating-slab expansion joints, using 1/0 AWG, Class G, stranded insulated conductor exothermically welded to transverse collector bar.

C. Fabricated Gray-Iron or Ductile-Iron Tunnel-Lining Segments:

1. Bond gray-iron or ductile-iron segments as shown in accordance with Sections 02415 and 02416.

D. Fabricated Steel Tunnel-Lining Segments:

Bond steel segments as shown in accordance with Sections 02415 and 02417.

E. Metallic Pipe:

1. Bond across joint for the following pipe, pipe fittings and pipe appurtenances, except those welded or soldered joints, using 2 AWG insulated conductor as shown and in accordance with Section 15205.

a. Buried pipe, except soil pipe unless shown bonded.

b. Pressure pipe.

c. Mechanical joints of fire line piping within tunnels.

d. Pipe parallel to and determined through testing to be an “affected structure” as determined in the Baseline Survey.

2. Do not bond non-WMATA pipes.

F. Permanent Metal Piles:

1. Interconnect permanent metal piles, except those used in ground grid, using 4/0 AWG insulated conductor exothermically welded to piles. At each end of line of bonded piles, connect 4/0 AWG insulated conductor and terminate in a

flush mounted test box inside the line structure. Identify conductor termination using non- metallic tags or plastic labels attached to conductor with slip-free plastic lacing or nylon bundling strap.

G. Drainage Cables in Tunnel, At-Grade and Aerial Sections:

1. Between bonded reinforcing steel and dc negative switchboard in traction- power substation, install stray-current drainage cable in accordance with the following requirements:

a. Adjacent to each traction-power substation, install two 250 kcmil, Class G, stranded insulated conductors, one end of each conductor welded to the reinforcing steel which has been bonded as specified herein, and the other end terminated in 12-inch by 18-inch by 4-inch junction box for each bonded structure.

b. From each junction box along each bonded “Inbound” and “Outbound” structure, install a 250 kcmil insulated cable in a 2-inch FRE conduit. The conduits and cables shall be terminated in a single surface mount 12-inch by 18-inch by 4-inch junction box located in the area of the dc negative switchboard in the traction power substation. Sufficient slack shall be left in each cable to allow extension of the cables to the dc negative switchboard for future connection by others if required. Label cables in surface mount junction box “Inbound Drainage Cable” or “Outbound Drainage Cable” as appropriate.

H. Electrically isolate reinforcing steel and other buried metallic structures, bonded for stray current and cathodic protection, from the ground grid, grounding electrode, or exposed metallic structures grounded for personnel safety. Metallic contact or electrical bonding between the two systems is prohibited.

I. Stray Current Test Facilities:

1. Stray current test facilities are to be installed at each end of each bonded structure and at maximum 500-foot intervals along each bonded structure as shown on the Contract Drawings.

2. Steel bolts/studs are to be welded onto the 6-inch by ¼-inch steel plates inside the cable trough along the aerial structures at the locations shown on the Contract Drawings.

3. Bond two 4/0 AWG cables from each pile drainage location to the test station facility as shown on the Contract Drawings.

4. Bond two 4 AWG cables from the reinforcing steel to the test station facility as shown on the Contract Drawings.

5. Test station facilities with 4/0 AWG pile drainage cables shall have an empty capped conduit installed for future use as shown on the Contract Drawings.

3.3 FIELD QUALITY CONTROL

A. Test Equipment

1. Provide a list of all testing equipment and devices including calibration certifications.

B. Grounding System

1. Test ground resistance of each ground grid after installation and each

ground bus when connected to ground grid, using approved test procedure. Record and submit readings in an approved test form.

2. Ground resistance not to exceed the following:

   a. Ground grid/bus in traction-power substations: Two (2) ohms.

   b. Ground grid/bus in ac-switchboard rooms, and chiller plants: Five (5) ohms.

   c. Ground grid/bus in electrical rooms, dispatcher rooms, telephone system rooms, mechanical rooms and dc tie- breaker stations: Five (5) ohms.

3. To meet resistance requirements, install additional ground rods or utilize permanent metal piles as supplemental ground rods. In soils of high resistivity and in rock construction where normal grounding grid design does not provide required low resistance, alternative methods of grounding grid design, or location, or soil treatment, are to be submitted to the Authority for approval.

4. Electrically isolate permanent metal piles used for grounding from those bonded for stray current and cathodic protection.

5. Test metallic conduits and raceways, metallic enclosures for equipment, metallic cable troughs, fences, metallic hand railings, metallic safety walk gratings, metallic structures, metallic covers, cover frames and bodies of manholes, hand holes and junction boxes, frames of shelters, pylons and dioramas, map case and telephone enclosures, and poles for mounting lighting fixtures to ensure continuity to grounding system.

6. Grounding conductors shall be carried in non-metallic conduits unless an engineering analysis determines a metallic conduit is necessary. Use of metallic conduit to carry a grounding conductor shall be submitted to the Authority for approval prior to installation. Where carried in metallic conduits, grounding conductors shall be bonded to the metallic conduit at each end of the conduit.

7. Test resistance of connections between the ground bus in train-control rooms/communications rooms and ground bus in associated ac-switchboard rooms, dc tie-breaker stations or traction-power substations to ensure resistance does not exceed one ohm.

8. Inspect and test exothermic welds as follows:

   a. Inspect finished exothermic welds for visual characteristics such as puffing, convex or caving that are consistent with a properly made connection in accordance with the manufacturer's instructions and recommendations. Remove welds that do not meet minimum visual requirements as acknowledged by the Authority, and re-weld after cleaning the area to be welded.

   b. Test mechanical strength of exothermic weld by applying three sharp blows to the weld with a 2-pound hammer using 15-inch strokes. Acceptable welds shall sustain the blows without cracking the weld metal or the bond between the two connecting materials. Remove defective welds and re-weld after cleaning the area to be welded.

C. Stray Current Corrosion Control Measures on Reinforcing Steel

1. General: The purpose of these tests is to determine the longitudinal resistance of welded reinforcing steel in precast and poured concrete aerial structure

decks, floating slabs, abutments and retaining walls. The tests shall also include verifying the electrical continuity of bonded H-Piles in foundations for retaining walls, abutments, piers and traction power substations. The Authority's representative will witness tests to ensure proper operation and compliance of installed measures in accordance with contract requirements and plan details of the Stray Current Corrosion Control system. The Contractor shall coordinate with the Authority to schedule field tests with the Authority's representative, at least two weeks in advance. Note: In the event field tests indicate deficiencies in the system, the Contractor will be responsible for all costs associated with correcting deficiencies, re- testing the Stray Current Corrosion Control system, including payment for additional site visits by the Authority's representative, at no additional cost to the Authority. The contractor shall provide:

a. Test Data Forms: Record test data in a uniform format pre-approved by the Authority. Include date and time of test, ambient temperature, test data, personnel, and instrumentation used on each sheet.

b. Testing Summary:

1) Pre-Pour Inspections/Tests:

a) Physical inspection of welds and test wires and electrical integrity tests of test wires

2) Post-Pour Tests:

a) Continuity tests along bonded structure

3) Improper materials or installation determined by QC tests, and/or tests performed by the Authority, shall be corrected at the sole expense of the Contractor.

2. Pre-Pour Inspections/Tests:

a. Subsequent to exothermic welding and after weld has cooled; test each weld as recommended by the manufacturer.

b. Prior to pouring of concrete, visually inspect all welds.

c. Prior to pouring of concrete, visually inspect all test wires and test stations for proper installation and positioning.

d. Prior to pouring of concrete, verify the electrical continuity of each test wire to the structure by measuring the resistance from the end of the test wire to the structure. Calculate the resistance using Ohm's Law by impressing a direct test current across the length of wire and measuring resultant voltage drop across same length of wire or by using a direct read low resistance ohmmeter that is designed for such applications.

1) Documentation: Include applied test current, measured voltage before application of current, with current applied and immediately after interrupting test current, calculated resistance and corresponding theoretical resistance in test report.

2) Acceptance Criterion: Maximum acceptable resistance is 120 percent of the product of the theoretical resistance per unit length, for the specific size and type of wire under test.

3. Post-Pour Tests:

a. Verify the electrical continuity of each pair of test wires to the structure

by measuring the resistance from the end of one of the test wires to the end of the other test wire using Ohm's Law by impressing a direct test current between the two test wires and measuring resultant voltage drop between the two test wires or by using a direct read low resistance ohmmeter that is designed for such applications.

1) Documentation: Include applied test current, measured voltage before application of current, with current applied and immediately after interrupting test current, calculated resistance and corresponding theoretical resistance (Paragraph below) in test report.

2) Acceptance Criterion: Maximum acceptable resistance is 110 percent of the summation of the following two items:

a) Product of the length of each test wire multiplied by the theoretical resistance per unit length, for the specific size and type of test wire under test.

b. Verify the electrical continuity of bonded structures between adjacent test stations by measuring the resistance along the structure. Calculate the resistance using Ohm's Law by impressing a direct test current between the one of the test wires in each of the adjacent test stations and measuring resultant voltage drop between the other test wires in each of the adjacent test stations or by using a direct read low resistance ohmmeter that is designed for such applications.

1) Documentation: Include applied test current, measured voltage before application of current, with current applied and immediately after interrupting test current, calculated resistance and corresponding theoretical resistance (Paragraph below) in test report.

2) Acceptance Criterion: Maximum acceptable resistance is 110 percent of the summation of the following two items:

a) Length of structure between points of connection of each test wire multiplied by the theoretical per unit resistance of the specific structure to which the test wires are connected.

b) Number of bonded expansion/contraction type joints along section of structure under test multiplied by the theoretical resistance of each bonded joint, determined by the number and length of the bond wire(s) across each joint and the wire gauge of the bond wire(s).

4. Failure to meet any acceptance criterion shall be reported to the Authority. Corrective action shall be taken by the contractor at the Contractor's sole expense.

END OF SECTION

SECTION 16120

WIRE, CABLE AND BUSWAYS FOR PASSENGER STATIONS

PART 1 – GENERAL

1.1 DESCRIPTION

A. This section specifies work pertaining to wire, cable and busways. Requirements for single-conductor cable and for multiple-conductor cable as stated except as otherwise specified.

B. Related Work Specified Elsewhere

Section 16052: Basic Materials and Methods for Traction Power

Section 16130: Raceways and Boxes for Electrical Systems

Section 02320: Grading, Excavating and Backfilling

Section 16125: Wire Connection Accessories

1.2 QUALITY ASSURANCE:

A. Qualifications: Manufacturer experienced in production of similar wire and cable, particularly to Railway or Transit industry in USA.

B. Codes, Regulations, Reference Standards and Specifications:

1. Codes and regulations of the Authority Having Jurisdiction including related items in the technical specifications.
2. National Electrical Code (NEC) 2011 Edition.
3. Insulated Cable Engineers Association (ICEA): S-95-658, S-96- 659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570, T-33-655.
4. IEEE: 1202 IEEE Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies.
5. National Electrical Manufacturers Association (NEMA): BU1, WC70, WC71, WC74.
6. UL: 44, Rubber-Insulated Wires and Cables Thermoset-Insulated Wires and Cables; 62, Flexible Cord and Fixture Wire; 857, Electric Busways and Associated Fittings; and 1581, Standard for Electrical Wires, Cables, and Flexible Cords; UL: 1072, Medium Voltage Power Cables; 1685, Standard for Safety Vertical-Tray Fire Propagation and Smoke release test for Electrical and Optical-Fiber cables; 1666, Test for Flame Propagation height of Electrical and Optical Fiber cables installed vertically in shafts.
7. NFPA 262: Standard method of test for flame travel and smoke of wires and cables for use in air handling spaces.
8. Comply with NFPA 130 2014 edition.

9. American Standards of Testing and Materials (ASTM): B3-95, Standard Specification for Soft or Annealed Copper Wire; B8-99, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft; D471-98e1, Standard Test Method for Rubber Property-Effect of Liquids, E662-97, Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials.
10. ITS: Directory of ITS Listed Products.
11. The equipment manufacturer shall maintain an ISO 9001: 2008 edition.
12. Virginia Uniform Statewide Building Code (2012).
13. Maryland International Building Code
14. District of Columbia Building Code

C. Source Quality Control:

1. Wire, cable and busways: Listed or labeled per UL or ITS directory.

1.3 SUBMITTALS

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

A. Product Data.

B. Certification:

1. Certified flame-retardancy test reports and data for tests performed not more than 12 months prior to submittal, for materials which are identical to those of cable furnished.
2. Submit smoke-density test reports and data for tests performed on the jacket material not more than 12 months prior to the submittal, for materials which are identical to those of the furnished cable.
3. Certified test reports demonstrating that cable complies with specified requirements and those of referenced ICEA applicable Standards.
4. Certificates from manufacturers verifying that products wire and cable conform to specified requirements. Include certificate with submittal of shop drawings and with each cable shipment.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Mark each single-conductor cable, each multiple-conductor cable and each busway to show UL Type, Listing/certifications, size, voltage, manufacturer and number of conductors or phases in accordance with NEC requirements.

B. Ship each unit securely packaged and labeled for safe handling and shipment.

C. Store products in a dry and secure facility.

1.5 NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) REQUIREMENTS

A. All station related wire and cable systems shall meet the requirements of 2014 Edition of NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail Systems.

B. All train way related wire and cable systems shall meet the requirements of 2014 Edition of NFPA 130 Standard for Fixed Guideway Transit and Passenger Rail Systems.

C. Where applicable, all emergency ventilation related wire and cable systems shall meet the requirements of the 2014 Edition of NFPA 130 Standard for Fixed Guideway Transit and passenger Rail Systems.

D. All conductor insulations shall conform to article 310 of NFPA 70 and shall be moisture and heat resistant types carrying temperature ratings corresponding to the conditions of application and in no case lower than 90 degrees Celsius (194 degrees Fahrenheit) for dry locations.

E. In the event that compliance with NFPA 70 or 130 will produce non- compliance with the requirements of this Specification, the NFPA shall take precedence.

PART 2 – PRODUCTS

2.1 PRODUCTS AND MATERIALS

A. General Requirements for Single-Conductor and Multiple-Conductor Cable:

1. Type and size: As shown.
2. Rated voltage: As shown.
3. Conductors:
   a. ASTM B3 or B8 annealed copper.
   b. Size 10 AWG and smaller: Solid or Class B or Class C stranded.
   c. Size 8 AWG and larger: Class B stranded.
4. Standards: Except as modified, wires and cable complying with the following standards:
   a. NFPA 130(2014) requirements.
   b. Cross-linked polyethylene (XLPE) insulated cable: ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570.
   c. Other cable: ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570.
5. Non-metallic jacket for single-conductor cable and an overall covering on multiple-conductor cable:

a. Chlorosulfanated polyethylene or cross-linked polyolefin.

b. Cross-linked polyolefin complying with the following physical requirements. Properties tested in accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, and S-81-570 if ethylene-propylene-rubber (EPR) insulation is used, or with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692 if cross-linked polyethylene insulation is used. Jacket and insulation material free of PVC and PVC-based compounds.

1) Tensile strength, minimum pounds per square inch: 1,800.

2) Elongation at rupture, minimum percent: 150.

3) Aging requirement: After 168 hours in air oven test at 100 degrees Celsius, plus-or-minus one degree Celsius:

a) Tensile strength, minimum percentage of unaged value: 100.

b) Elongation at rupture, minimum percentage of unaged value: 80.

4) Oil immersion: 18 hours at 121 degrees Celsius, plus- or-minus one degree Celsius, ASTM D471, Table 1, No. 2 oil:

a) Tensile strength, minimum percentage of unaged value: 80.

b) Elongation at rupture, minimum percentage of unaged value: 80.

c. Jacket materials other than cross-linked polyolefin complying with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692. Jacket and insulation material free of PVC and PVC-based compounds.

6. Flame retardancy: Single-conductor and multiple-conductor cable tested by independent agency demonstrating flame retardancy in accordance with the following:

a. Single-conductor cable and individual conductors of multiple- conductor cable passing vertical wire flame test in accordance with UL1581 or UL1685. Cable size for testing: 14AWG.

b. Single-conductor cable , size 1/0 AWG and larger, passing vertical tray flame test, using ribbon gas burner in accordance with IEEE 1202. Cable size for testing: 1/0 AWG.

c. Multiple conductor cable passing vertical tray flame test using ribbon gas burner in accordance with IEEE 383 or IEEE 1202. Cable size for testing: 7/C or 9/C with No. 12 AWG or No. 14 AWG conductors.

7. Smoke generation: Single and multiple-conductor cable jacket materials demonstrating low-smoke generation when tested in accordance with ASTM E662 or NFPA 262 by independent, nationally recognized testing agency.

a. Conduct tests on specimens of overall jacket material for multiple-conductor cable and of jacket material for single- conductor cable.

b. Prepare slab specimens for each material.100 inch, plus-or- minus .005-inch thick, identical to those of finished cables and meeting minimum physical requirements specified.

1) Prior to testing, submit six-inch square portion of each specimen. Tag sample with manufacturer's jacket or insulation identification code or number.

c. Test values for Chlorosulfanated polyethylene not to exceed the following:

1) Flaming mode:

a) Uncorrected maximum specific optical density during first four minutes of test: 325.

b) Uncorrected maximum specific optical density for entire 20-minute test: 400.

2) Non-flaming mode:

a) Uncorrected maximum specific optical density' during first four minutes of test: 325.

b) Uncorrected maximum specific optical density for entire 20-minute test: 480.

d. Test values for cross-linked polyolefin not to exceed the following:

1) Flaming mode:

a) Uncorrected maximum specific optical density during first four minutes of test: 50.

b) Uncorrected maximum specific optical density for entire 20-minute test: 250.

2) Non-flaming mode:

a) Uncorrected maximum specific optical density during first four minutes of test: 50.

b) Uncorrected maximum specific optical density for entire 20-minute test: 350.

8. Wire and cable constructions intended for use in power circuits to emergency lights, and so forth shall be listed as being resistant to the spread of fire and have a minimum 1-hour fire-resistive rating in accordance with ANSI/UL 2196 and shall also have reduced smoke emissions by complying with the following:

a. Cable shall be permitted to be listed in accordance with any of the following methods:

1) The cable does not spread fire to the top of the tray in the vertical-tray flame test in UL 1581, Section 1160, and the cable exhibits a specific optical density of smoke at 4 minutes into the test that does not exceed 200 (in the flaming mode) or 75 (in the non- flaming mode), when tested in accordance with ASTM E 662.

2) The cable exhibits damage (char length) that does not exceed 1.5 m (4.9 ft.) when the vertical flame test, with cables in cable trays, is performed as described in CSA C22.2 No. 0.3, and the cable exhibits a specific optical density of smoke at 4 minutes into the test that does not exceed 200 (in the flaming mode) or 75 (in the non- flaming mode), when tested in accordance with ASTM E 662.

3) The cable listed as a limited smoke cable (LS) by meeting the cable damage height, total smoke released, and peak smoke release rate criteria required when tested in the vertical tray flame test in UL 1685. The following performance criteria shall be met when testing accordance to UL 1685.

a) When testing in the UL vertical tray flame exposure:

i) The cable damage height shall be less than 2.44 m (8 ft.) when measured from the bottom of the cable tray.

ii) The total smoke released shall not exceed 95m² (1023 ft²).

iii) The peak smoke release rate shall not exceed 0.25m²/s (2.69 ft²/s).

b) Alternatively, when testing in the IEEE 1202 flame exposure:

i) The cable damage height shall be less than 1.5 m (4.9 ft.) when measured from the lower edge of the burner face.

ii) The total smoke released shall not exceed 150m² (1615 ft²).

iii) The peak smoke release rate shall not exceed 0.40m²/s (4.3 ft²/s).

4) The cable is listed as having fire-resistant characteristics capable of preventing the carrying of fire from floor to floor, by being capable of passing the requirements of ANSI/UL 1666, and the cable exhibits a specific optical density of smoke at 4 minutes into the test that does not exceed 200 (in the flaming mode) or 75 (in the non-flaming mode), when tested in accordance with ASTM E 662.

5) The cable is listed as having adequate fire-resistant and low-smoke-producing characteristics, by having a flame travel distance that does not exceed 1.52 m (5 ft.), generating a maximum peak optical density of smoke of 0.5 and a maximum average optical density of smoke of 0.15 when tested in accordance with NFPA 262.

9. Applied voltage testing:

a. Single-conductor cable and individual conductors of multiple- conductor cable to be given applied AC voltage dielectric-strength test, i.e., six-hour water-immersion test.

b. For single conductors of multiple-conductor cable, conduct tests prior to assembly as multiple-conductor cable.

c. Test procedures:

1) Polyethylene-insulated conductors: In accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692.

2) Other conductors: In accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, and S-81-570.

10. Single and multiple – Conductor cables shall be listed as fire resistive cables used for emergency lighting and shall be listed and have a minimum one hour fire resistive rating in accordance with UL2196 and be installed per the listing requirements.

B. Single-Conductor Cable:

1. Insulated with ethylene-propylene-rubber with non-metallic jacket, Chlorosulfanated polyolefin, or cross-linked polyolefin as specified. UL-Labeled as Type RHW-2.

2. Color coding: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.

C. Multiple-Conductor Cable:

1. Individual conductors:

a. Number of conductors: As required.

b. Construction: Complying with one of the following:

1) Insulated with ethylene-propylene-rubber, with or without non-metallic jacket.

2) Insulated with composite compound of ethylene- propylene- rubber and polyethylene, without outer jacket.

3) Insulated with filled cross-linked polyethylene without jacket.

c. Phase and neutral conductors: Individually insulated.

d. Neutral conductors: Same size as phase conductors.

e. Bare ground conductors: Sized in accordance with the NEC, unless otherwise shown.

f. UL Listed as Type RHW-2 or XHHW-2. Low Smoke Zero Halogen.

2. Conductors assembled with non-wicking, flame-retardant filler to form cable of circular cross section.

3. Metallic sheath:

a. Provide one of the following:

1) Size 1 AWG and larger:

a) Interlocked aluminum-tape armor.

b) Continuous corrugated aluminum sheath conforming to ICEA S-19-81, Table 4-26A.

2) Size 2 AWG and smaller: As specified for 1 AWG and larger or continuous smooth aluminum sheath conforming to ICEA S-95- 658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692.

b. Metallic covering not required for multiple-conductor TC cable with overall non-metallic jacket when installed in cable tray.

4. Multiple-conductor cable provided with overall non-metallic jacket as specified.

5. Cable UL-listed as follows:

a. Non-metallic-sheathed cable: Type TC, suitable for wet and dry locations.

b. Metallic-sheathed cable: Type MC, suitable for wet and dry locations.

6. Color coding:

a. Power cables: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.

b. Control cables: In accordance with ICEA S-95-658, S-96- 659, S-93-639, S-94-649, S-97-682, and S-105-692.

D. Fixture Wire: UL 62, with the following additional requirements:

1. Type: SF-2 silicone-rubber insulated or as necessary to suit temperature rating of lighting fixture, minimum 90 degrees Celsius.

2. Conductor: Stranded copper conductor 16AWG or larger as required.

E. Bare Conductors: ASTM B3 or B8, annealed copper conductor; 8AWG and larger, Class B stranded, unless otherwise shown or specified.

F. Medium Voltage Single-Conductor Cable:

1. Rated voltage: 15-kV, 35-kV.

2. Conductor: As specified and with an extruded semi-conducting strand screen.

3. Insulation: Ethylene-propylene rubber, 133 percent insulation level, with an extruded semi-conducting insulation screen.

4. Shield: Copper tape, minimum thickness 2.5 mils, with a minimum of 25% overlap.

5. Jacket: Overall nonmetallic jacket of chloro-sulfonated polyethylene or cross-linked polyolefin with low smoke, flame retardant, zero halogen characteristics in accordance with UL standard 1072 and ICEA T-33-655.

G. Medium Voltage Cable Terminations:

1. Except as otherwise specified, heat shrinkable tubing kit type, with grounding accessory kits, in accordance with the characteristics of the medium voltage cable shall be furnished.

   a. Shrinkable tubing kits to be pre-stretched shrinkable tubing and shall contain all necessary components to reinstate cable insulation, metallic shielding/grounding system and overall jacket.

H. Busway (Bus duct) and Fittings:

1. NFPA 130: Conduits, raceways, ducts, boxes, cabinets, and equipment enclosures shall be constructed of noncombustible materials in accordance with the requirements of ASTM E 136.

2. UL 857, NEMA BU1.

3. Totally enclosed, three-phase, four-wire feeder busway system, as required, with necessary fittings, hanging devices, accessories and provision for flange bolting over circuit breaker.

4. Continuous current rating:

   a. Secondary tie duct for use in combined substation: Sized in accordance with ANSI C37.20.1, C37.20.2, C37.20.3, and NEC.

5. Voltage rating: 480/277 Volts.

6. Busway system braced to withstand minimum short-circuit current of 65,000 amperes symmetrical but not less than the highest short- circuit current available upstream and downstream of the busway system, unless otherwise shown and based on the short circuit study.

7. Maximum allowable temperature rise in busway at continuous full load above maximum ambient temperature of 40 degrees Celsius: 55 degrees Celsius.

8. Housing: Nonventilated, fabricated from galvanized sheet steel or aluminum. If aluminum is used, the thickness shall be modified to provide equivalent strength and deflection to that of steel. Removable gasketed cover provided at transformer connection for maintenance and test. Hardware galvanized or cadmium-plated.

9. Joints:

   a. Single-bolt pressure joint designed for optimum electrical contact and mechanical strength.

   b. To permit safe testing of its tightness without de-energizing systems.

   c. To permit removal of duct sections without disturbing adjacent pieces.

   d. To permit making up joint from one side when busway is installed against wall or ceiling.

10. Busbars: Fabricated from 98-percent-conductivity copper and insulated over entire length except at joints and contact surface. Joints and contact surfaces tin- plated or silver-plated. Neutral bar same size as phase bar. Ground bar half size of phase bar.

11. Entire busway system polarized.

12. Expansion fittings provided where necessary.

13. Flexible connections, braided or laminated, provided for connecting bus conductor to transformer terminals.

14. Finish: Light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.

I. Variable Frequency Controller (VFC) Cable:

1. Comply with UL 1277, UL 1685, ICEA S-95-658, and NFPA 70 for Type TC-ER cable.
2. Type TC-ER with oversized cross-linked polyethylene insulation, dual spirally wrapped copper tape shields and three bare symmetrically applied ground wires. Jacket and insulation material free of PVC and PVC based compounds.
3. Comply with UL requirements for cables in direct burial Class I and II, Division 2 hazardous location applications.

J. VFC Output Circuits: Type XHHW-2 in Rigid Metal Conduit, Type TC-ER cable with dual tape shield. Jacket and insulation material free of PVC and PVC based compounds.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install type cable as specified.

B. Install single-conductor cable in conduit, underfloor duct or wireway. Install UL Type TC multiple-conductor cable in cable trays only. Install UL Type MC multiple-conductor cable and ground cable on channel inserts, cable trays, racks, trench or trough using straps and fasteners as specified in Section 26 05 33. Install UL Type MC multiple-conductor cable in conduit where shown or required. On walls or ceilings, fasten cable and bus duct directly to channel inserts, or use expansion-bolt anchors to attach to concrete and toggle bolts to attach to concrete masonry unit walls. Splice cable only when unavoidable.

C. Install motor feeders, service connections and extensions in accordance with reference codes. Install motor feeder in 18-inch minimum length liquid-tight flexible conduit at motor conduit box.

D. Use nylon straps to bundle and secure wire and cable located in panelboards, cabinets, switchboards, motor control centers and switchgear.

E. Minimum bending radius 12 times outer diameter of cable. Where shown, use shorter bending radius as permitted by NEC, ICEA S-95-658, S-96- 659,S-93-639, S-94-649, S-97-682, and S-105-692, and cable Manufacturer.

F. To facilitate pulling cable, use listed per UL or ITS directory lubricant recommended by cable manufacturer.

G. Use direct-burial cable only for stray current and cathodic protection.

H. To install direct-burial cable, prepare trench of uniform width and free of sharp projections and rocks and place 3-inch bed of sand. Do not pull cable directly into trench from stationary reel; unreel cable beside trench. Place cable on sand bed and backfill with 3- inch deep sand cover. Fill remainder of trench with approved fill material and compact in accordance with Specification Section 31 22 00. Provide temporary supports in trench as necessary to prevent damage to insulation or jacket during installation.

I. In damp and dusty indoor locations, manholes and outdoor locations, seal cable at conduit termination using duct-sealing compound.

J. Where shown or necessary, install cable-seal fitting specified in Section 26 05 33 to prevent entry of water into electrical facilities. Where approved, use seal compound specified in Specification Section 26 05 33.

K. Use polyethylene or other suitable nonmetallic rope for pulling cable. Attach to cable by means of either woven basket grips or pulling eyes attached directly to the conductors.

L. Support cable installed in manholes at each invert location with cable brackets, racks and insulators specified in Section 34 21 11. Provide brackets of suitable length with one insulator for each cable.

M. Terminate medium voltage cable, using the specified termination kits, in accordance with the manufacturer's recommendations.

N. The splicing of power and control cables is not permitted in duct banks, cable troughs or cable trenches. However, if permitted by W M A T A , make watertight splices as approved.

3.2 IDENTIFICATION

A. Identify cable terminations, feeders and power circuits using non-metallic fiberboard tags or plastic labels. Attach tags to cable with slip-free plastic lacing or nylon bundling straps. Use designation shown on Contract drawings.

3.3 FIELD QUALITY CONTROL

Engage a qualified testing and inspection agency to ensure that the work is in conformance with applicable specifications and perform tests required by these specifications:

A. Submit test procedures in accordance with the Contract documents for approval and perform approved tests. Do not perform tests without approved test procedure. Furnish the equipment, personnel to perform the following tests:

1. 600V AC power Single-conductor cable and multiple-conductor cable:

   a. Test continuity of cable conductors using ohmmeter.

   b. Proof-test insulation resistance to ground and between insulated conductors for minimum of one minute using 1,000-Volt megger. Insulation resistance: 200,000 ohms minimum.

   c. When cable shows unsteady insulation resistance of less than 200,000 ohms, perform high-potential test at 80 percent of factory AC test voltage or as recommended by cable manufacturer.

2. 15kV, 35kV Medium Voltage Cable: Single-conductor cable

   a. Test continuity of conductors using ohmmeter.

   b. Proof-test insulation resistance between conductor and the metallic shield. While conducting the test, the metal shield shall be tied to ground. Insulation resistance shall be measured with a 2500-Volt megger for minimum of one minute. Insulation resistance: 500 megohm minimum corrected to 15.6 degrees Celsius.

   c. Submit certified test reports within 30 days after completion of test.

3. Busway:

   a. Clean contact surfaces before making connections. For bolted connections, apply torque recommended by manufacturer.

   b. Test resistance of busway connections. Resistance not to exceed value

recommended by manufacturer.

c. Test insulation resistance to ground and between insulated busbars for minimum of one minute using 1,000-Volt megger. Insulation resistance: One-megohm minimum. When busway shows insulation resistance of less than one- megohm minimum, perform high-potential test.

B. Prior to insulation and high-potential tests, disconnect instruments and equipment which might be damaged during such tests. Conduct tests in accordance with the Contract Documents.

C. Submit certified test reports.

END OF SECTION

SECTION 16125

WIRE CONNECTION ACCESSORIES

PART 1 - GENERAL

1.1 DESCRIPTION:

A. This section specifies providing wire-connection accessories, such as connectors, terminal lugs and fittings, bundling straps, insulating tape and resin.

1.2 QUALITY ASSURANCE:

A. Qualifications: Select a manufacturer who is engaged in production of similar wire connection accessories.

B. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. National Electrical Code (NEC).
3. UL: 486A, Wire Connectors and Soldering Lugs for Use with Copper Conductors.
4. American Standards of Testing and Materials (ASTM): D149-97a, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies; D257-99, Standard Test Methods for DC Resistance or Conductance of Insulating Materials; D412-98a, Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers-Tension; D570-98, Standard Test Method for Water Absorption of Plastics; D638-00, Standard Test Method for Tensile Properties of Plastic; D696-98, Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30°C and 30°C with a Vitreous Silica Dilatometer; D792-00, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement; D1000-99, Standard Test Method for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications; D1518-85(1998)e1, Standard Test Method for Thermal Transmittance of Textile Materials; D5034-95, Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test); D5035-95, Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method); D2240-00, Standard Test Method for Rubber Property-Durometer Hardness; and G21-96, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
5. American National Standards Institute (ANSI): C119.1, Sealed Insulated Underground Connector System 600V
6. ITS: Directory of ITS Listed Products.

C. Source Quality Control:
1. Connectors, terminal lugs and fittings listed, per referenced UL or ITS directory.
2. Factory testing: Submit certified copies of test report for cable splice and tap-insulation/sealing kits as specified.

1.3 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Shop Drawings.
   2. Certification.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Mark each item in accordance with applicable reference standard.

B. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage.

C. Store products in secure and dry storage facility.

PART 2 - PRODUCTS

2.1 PRODUCTS AND MATERIALS:

A. Connectors, Terminal Lugs and Fittings:
   1. In accordance with UL 486A.
   2. For 10AWG and smaller conductor cable: Tin-plated copper pressure connectors with nonflammable, self-extinguishing insulation grip with temperature rating equal to that of conductor insulation.
   3. For 8AWG to 4/0 AWG conductor cable: Tin-plated copper compression connectors and terminal lugs with nylon insulating sleeve for insulation grip.
   4. For 250 Kcmil and larger conductor cable: Long-barrel, double-compression tin-plated copper connectors and terminal lugs with two-hole pad.
   5. For multiple-conductor cable: Watertight aluminum fittings with stainless-steel pressure ring and set screws or compression cone for grounding of aluminum sheath of MC Cable.

B. Bundling Straps:
   1. Self-locking steel barb on one end, with tapered strap of self-extinguishing nylon, temperature rating minus 40F to plus 185F.
   2. For outdoor use: Ultraviolet-resistant.

C. Insulating Tape:
   1. Plastic tape: Vinyl plastic tape with rubber-based pressure-sensitive adhesive, pliable at zero degree F with the following minimum properties when tested in accordance with ASTM D1000-99:
      a. Thickness: 8.5 mils.
      b. Breaking strength: 20 pounds per inch width.
      c. Elongation: 200 percent.
      d. Dielectric breakdown: 10,000 volts.
      e. Insulation resistance, indirect method of electrolytic corrosion: 1,000,000 megohms.
   2. Rubber tape: Silicone-rubber tape with silicone pressure-sensitive adhesive, with the following minimum properties when tested in accordance with ASTM D1000-99:

a. Thickness: 12 mils.
b. Breaking strength: 13 pounds per inch width.
c. Elongation: 525 percent.
d. Dielectric breakdown: 13,000 volts.
e. Insulation resistance, indirect method of electrolytic corrosion: 1,000,000 megohms.

3. Arcproof tape: Flexible, coated one side with flame-retardant flexible elastomer, self-extinguishing, non-combustible, with the following minimum properties:
   a. Thickness, ASTM D1000: 30 mils.
   b. Breaking strength, ASTM D5034-95 and D5035-95: 50 pounds per inch width.
   c. Thermal conductivity, ASTM D1518-85: 0.0478 BTU per hour per square foot per degree F.
   d. Electrical arc resistance: Withstand 200 amperes arc for 30 seconds.
4. Glass tape: Woven-glass fabric tape with pressure-sensitive thermosetting adhesive, with the following minimum properties when tested in accordance with ASTM D1000-99:
   a. Nominal width: 3/4 inch.
   b. Thickness: Seven mils.
   c. Breaking strength: 170 pounds per inch width.
   d. Elongation: Five percent.
   e. Dielectric breakdown: 2,500 volts.
   f. Insulation resistance, indirect method of electrolytic corrosion: 5,000 megohms.

D. Epoxy Resin: Suitable for insulating and moisture sealing cable splices, with the following minimum properties:
1. Dielectric strength, ASTM D149-97a: 400 volts per mil.
2. Volume resistance, ASTM D257-99: 2.8×10^{15} ohm per centimeter cube at 30C.
3. Water absorption, ASTM D570-98:
   a. 0.193 percent in 24 hours at 23C.
   b. 0.62 percent in 24 hours at 53C.
4. Tensile strength, ASTM D638-00: 8,000 psi.
5. Elongation, ASTM D638-00: 2.4 percent.
6. Coefficient of expansion, ASTM D696-98: 6.8 X 10-5 inch per inch per degree C.

E. Cable splice and tap-insulation/sealing kit: Suitable for use on 600-volt, 90C cables, material compatible with cable insulation and jacket, meeting the seal test requirements of ANSI C119.1.
1. Heat-shrinkable tubing or wraparound heat-shrinkable sleeve: approved per referenced UL or ITS directory, flame-retardant, corrosion-resistant thick-wall tubing with factory-applied sealant for field insulation on in-line splices and taps or wraparound-type sleeve for retrofit installation on existing splices and taps to provide a watertight seal and insulating encapsulation, with the following additional requirements:
   a. Material: Cross-linked polyolefin.
   b. Shrink ratio: 3 to 1 minimum.
   c. Physical properties:
      1) Ultimate tensile strength: 2,350 psi, ASTM D412-98a.
      2) Ultimate elongation: 350 percent, ASTM D412-98a.
      3) Hardness, Shore D: 42, ASTM D2240-00.
      4) Water absorption: 0.050 percent, ASTM D570-98, Method 6.1.

5) Specific gravity: 1.28, ASTM D792-00.

d. Electrical properties:
   1) Dielectric strength: 450 volts per mil, ASTM D412-98a.
   2) Volume resistivity: 1 x $10^{14\ ohm}$ cm, ASTM D257-99.

e. Thermal properties:
   1) Continuous operating temp.: -55C to +135C.
   2) Air oven aging (14 days at 175C):
      a) Tensile strength: 2,680 psi.
      b) Elongation: 375 percent.
   3) Low temp. Flexibility (4 hours at -55C): No cracking when flexed.
   4) Heat shock (4 hours at 250C): No cracking, flowing or dripping.

f. Chemical properties:
   1) Corrosively: Non-corrosive.
   2) Fungus resistance: Non-nutrient, ASTM G21-96.
   3) Flammability: Self-extinguishing.

PART 3 - EXECUTION

3.1 SPLICES AND TERMINATIONS:

A. Make wire and cable splices in outlet, junction or pull boxes, in cable troughs or in equipment cabinets. Splices in conduit are prohibited.

B. Secure connectors or terminal lugs to conductor so as to engage all strands equally.

C. Do not rupture insulation nor expose bare conductors.

D. Install compression connectors and terminal lugs using tools and pressure recommended by manufacturer. Indent mark connectors and terminal lugs with number of die used for installation.

E. Apply anti-corrosion joint compound to connectors, terminal lugs and bolting pads before installation.

F. Wrap ½-lapped layer of arcproof tape, glass tape overall on cable splices installed in air tunnels, ducts and shafts.

G. Install terminal fittings on multiple-conductor cable in accordance with manufacturer's recommendation. Completely seal cable from moisture.

H. On cable splices, taps and terminations in manhole handhole and outdoor junction and pull boxes, cover connectors with electrical putty, wrapped with three layers of plastic tape or final layer of rubber tape and then install watertight encapsulation as follows and under the supervision of kit manufacturer's representative or using a factory-certified installation technician, proficient in field installation of heat-shrinkable sealing kits.
   1. Use heat-shrinkable tubing for encapsulation of new splices, taps and terminations.
   2. Use wraparound-type heat-shrinkable sleeve for encapsulation of existing splices, taps and terminations.

3.2 CATHODIC PROTECTION SPLICES AND TERMINATIONS:

A. For splices made in aboveground cable, use compression connectors covered with electrical putty, wrapped with three layers of plastic tape and final layer of rubber tape.

B. Install compression terminal lugs using tools and pressure recommended by manufacturer. Indent mark terminal lugs with number of die used for installation.

C. For splices made in direct-burial cable, use thermite weld sealed with cast epoxy-resin encapsulation.

3.3 INSPECTION:

A. Have splices in direct-burial cable for stray current and cathodic protection inspected by the Engineer before backfilling.

B. Have splices and taps in manholes, hand holes and outdoor junction and pull boxes inspected by the Engineer or the manufacturer's representative, when available.

END OF SECTION

SECTION 16130

RACEWAYS BOXES AND CABINETS

PART 1 – GENERAL

1.1 DESCRIPTION

A. This section specifies work pertaining to conduit, raceways, cable trays, boxes and cabinets to form raceway and support system for power, communication and control cables.

1.2 QUALITY ASSURANCE

A. Qualifications: Select a manufacturer who is experienced in production of similar raceways, boxes and cabinets.

B. Codes, Regulations, Reference Standards and Specifications:

1. Comply with Codes and regulations of the Authority Having Jurisdiction.
2. Washington Metropolitan Area Transit Authority Manual of Design Criteria, latest edition
3. NFPA 70, National Electrical Code (NEC), 2011 Edition.
4. NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail System, 2014 Edition.
5. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum); VE 1, Metallic Cable Tray Systems; TC-2, Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.
6. American National Standards Institute (ANSI): C80.1, Rigid Steel Conduit - Zinc Coated; C80.5, Aluminum Rigid Conduit - (ARC); and Z55.1, Gray Finishes for Industrial Apparatus and Equipment.
7. UL: 5, Surface Metal Raceways and Fittings; 6, Rigid Metal Conduit; 50, Enclosures for Electrical Equipment; 94, Test for Flammability of Plastic Materials for Parts in Devices and Appliances; 360, Liquid Tight Flexible Steel Conduit; 514A, Metallic Outlet Boxes; 514B, Fittings for Conduit and Outlet Boxes; 514C, Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers; 651, Schedule 40 and 80 Rigid PVC Conduit; 884, Underfloor Raceways and Fittings; and 1684, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
8. Federal Specifications (FS): FF-S-325C, FF-S-760, TT-S-227.
9. American Standards of Testing and Materials (ASTM): A47/A47M- 99, Standard Specification for Ferritic Malleable Iron Castings; A123/A123M-00, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; A185-97, Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement; A276-00a, Standard Specification for Stainless Steel Bars and Shapes; A507-00, Standard Specification for Drawing Alloy Steel, Sheet and Strip, Hot-Rolled and Cold- Rolled; A532/A532M- 93a(1999)e1, Standard Specification for Abrasion-Resistant Cast Irons; A536- 84(1999)e1, Standard Specification for Ductile Iron Castings; A615/A615M-00, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement; A653/A653M-00, Standard Specification for Steel Sheet, Zinc-

Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; B138-96, Standard Specification for Manganese Bronze Rod, Bar and Shapes; B455- 96, Standard Specification for Copper-Zinc-Lead Alloy (Leaded-Brass) Extruded Shapes; B584-00, Standard Specification for Copper Alloy Sand Castings for General Applications; B633-98, Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel; C109/C109M-99, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens); C173-94ae1, Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method; C231- 97e1, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method; D149-97a, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies; D495-99, Standard Test Method for High- Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation; D570- 98, Standard Test Method for Water Absorption of Plastics; D638-00, Standard Test Method for Tensile Properties of Plastics; D648-00a, Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position; and D790- 00, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.

10. American Association of State Highway and Transportation Officials (AASHTO): Standard Specifications for Highway Bridges (SSHB).
11. ITS: Directory of ITS listed products.
12. The equipment manufacturer shall maintain ISO 9001: 2008 edition certification.
13. Virginia Uniform Statewide Building Code, 2009 edition

C. The following items to be listed or labeled per referenced UL or ITS directory:

1. Conduit and fittings.
2. Surface raceways and fittings.
3. Underfloor raceways and fittings.
4. Boxes.
5. Cabinets.

1.3 SUBMITTALS

A. Submit the following for approval in accordance with the Contract Documents, and with the additional requirements as specified for each:

1. Product Data submittal for conduit and fittings, raceways and fittings, cable trays, boxes, cabinets, and underfloor raceways and fittings.
2. Certification: Manufacturer certification that materials comply with specification requirements.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Mark each item in accordance with applicable reference standard.

B. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.

C. Store products in secure and dry storage facility.

PART 2 – PRODUCTS

2.1 PRODUCTS AND MATERIALS

A. General Requirements for Conduit, Raceways, Cable Trays, Boxes, Cabinets and Fittings:

1. Size: As shown, minimum conduit size 3/4 inch.
2. Materials:
   a. Steel sheet: ASTM A507-00.
   b. Zinc-coated steel sheet: ASTM A653/A653M-00. c.
   Cast iron: ASTM A532/532M-93a (1999) e1.
   d. Ductile iron: ASTM A536-84(1999) e1.
   e. Malleable iron: ASTM A47/A47M-99.
   f. Bronze extrusion: ASTM B455-96, Alloy C38500.
   g. Bronze casting: ASTM B584-00, Alloy C83600.
   h. Rigid fiberglass reinforced epoxy: UL 1684.
   i. Stainless steel: ASTM A276-00a, Type 304.
3. Zinc coating:
   a. Pre-galvanized sheet steel: ANSI/SAE 1008.
   b. Electro galvanizing: ASTM B633-98.
4. NFPA 130 version 2014 requirements:
   a. Materials manufactured for use as conduits, raceways, ducts, boxes, cabinets, equipment enclosures, and their surface finish materials shall be constructed of noncombustible materials in accordance with the requirements of ASTM E 136.

B. Galvanized-Steel Rigid Conduit and Fittings: UL 6 and ANSI C80.1, zinc coating tested in accordance with reference test in appendix.

C. Plastic Conduit and Fittings: (For Medium Voltage only):

1. PVC, UL 651, NEMA TC-2, Schedule 40 and 80 heavy-wall, for use with 90C conductors.
2. Solvent cement: Manufacturer's standard.

D. Aluminum Rigid Conduit and Fittings:

1. ANSI C80.5 and UL 6

E. Liquid-Tight Flexible Conduit and Fittings:

1. Applicable requirements of UL 360.
2. Flexible galvanized-steel core with extruded liquid-tight neoprene.
3. Sizes up to 1-1/4 inch provided with continuous copper bonding conductor, spiral wound between convolutions.
4. Sizes

5. 1-1/2 inch and above provided with separate grounding conductor.

6. No PVC compounds permitted.

F. Conduit Expansion Fittings and Expansion and Deflection Fittings:

1. Materials:

a. For galvanized-steel rigid conduit:

1) Expansion fittings: Steel or malleable iron, hot-dip galvanized. Threaded.

2) Expansion/deflection fittings: Bronze or ductile iron end couplings, neoprene sleeve and stainless steel clamping bands.

b. For PVC conduit: Rigid metal expansion/deflection fitting with galvanized rigid steel to PVC conduit adapters at each end.

2. Conduit expansion fitting: Weatherproof.

3. Conduit expansion and deflection fitting: Watertight.

4. Metallic fittings equipped with bonding jumper cable to provide electrical continuity.

G. Conduit Connector Fittings:

1. UL 514B, material and finish similar to that of conduit with which they are to be used. Threaded for steel rigid conduits.

2. For enclosures, cabinets, boxes and gutters in electrical rooms and aboveground indoor locations: Threaded nylon-insulated bushing and locknuts.

3. For enclosures, cabinets, boxes and gutters with hub in outdoor locations: Threaded watertight hub fitting with gasket.

4. For enclosure having punched or formed knockout for conduit entry in outdoor locations: Threaded watertight fitting with gasket, nylon- insulated throat and sealing locknut.

H. Conduit and Cable-Seal Fittings:

1. Conduit seal:

a. To provide watertight seal between concrete and conduit where it penetrates wall, floor or ceiling.

b. Size as shown or necessary.

c. Materials: Body and pressure clamp of malleable or cast iron with a neoprene sealing grommet and PVC-coated or galvanized-steel pressure rings, oversized sleeve of FRE or galvanized steel.

d. Seal between conduit and concrete to withstand pressure from 50-foot head of water without leakage.

2. Cable seal:

a. To provide watertight seal between cable and conduit for use with single-conductor or multiple-conductor cable as necessary.

b. Size as necessary, drilled to accommodate cable.

c. Pressure discs of PVC-coated steel and sealing ring of neoprene.

d. Seal between cable and conduit to withstand water pressure of 50 psi without leakage.

3. Seal compound:

a. FS TT-S-227, two-component, fast-setting, polymeric sealing compound to provide watertight seal between concrete and conduit, between cable and conduit.

b. Pour-type for horizontal and gun-grade for vertical or overhead application.

c. When cured, sealant to have rubber-like flexibility allowing minimum movement of conduit and cable in temperature range of minus 40 degrees Fahrenheit to plus 150 degrees Fahrenheit without loss of watertight seal.

d. Pot life: 15 minutes.

e. Minimum ambient temperature for application: 35ºF.

f. Initial cure: 15 minutes.

g. Final cure: Seven days.

h. Hardness, Durometer A: 20-35.

i. Seal between conduit and concrete to withstand pressure from 50-foot head of water without leakage.

j. Seal between conduit and single-conductor or multiple-conductor cable to withstand water pressure of 70 psi without leakage.

k. Fox Industries, Type FX-571G or approved equal.

I. Conduit and Cable Supports:

1. Retaining straps and fasteners: FS FF-S-760, with the following additional requirements:

a. Type, style and size: As necessary.

b. Material and finish: Stainless steel, Type 304, or approved equal.

c. For separating conduit from masonry surface: Hot-dip galvanized malleable-iron spacer assembled with Style A strap.

d. For vertical run of metallic-sheath cable: Basket-weave cable support.

e. For fastening conduit or cable to channel inserts: Stainless steel, Type 304.

2. Multiple pipe hangers (trapeze-type): Consisting of two or more hanger rods, horizontal member, U-bolt clamp and other attachment necessary for securing hanger rods and conduit, with the following additional requirements:

a. Material and finish: Stainless steel, Type 304.

b. Hanger rod: Not smaller than 3/8-inch diameter, threaded for sufficient distance at each end to permit at least 1-1/2 inches of adjustment.

c. Horizontal member: Channel, 1-1/2 square inches or 1-5/8 square inches by 12 gauges or heavier. Weld two or more channels together for greater strength if necessary.

d. Design: Capable of supporting load equal to sum of weights of conduit, cable and hanger plus 200 pounds. At design load, stress at root of thread on hanger rod 9,500-psi maximum; stress in horizontal member 12,500-psi maximum.

3. Channel inserts:

a. Size and shape as shown 12 gauges or heavier stainless steel, Type 304, or approved equal, with 7/8-inch wide slot.

b. For surface mounting: Channel inserts with 9/16-inch base slot, eight inches on center with minimum pullout-load rating of 1,000 pounds per linear foot.

4. Spot inserts: Rated 800 pounds with safety factor of five, fabricated from steel galvanized after fabrication, covered to prevent entrance of concrete during installation.

J. Surface Raceways and Fittings: UL 5, fabricated from galvanized steel.

K. Underfloor Raceways and Fittings: (For Passenger Stations only): 1. UL 884.

2. Size: As shown.

3. Fabricated from steel 14 gauges or heavier steel sheet.

4. Finish: Corrosion-resistant coating listed per referenced UL or ITS directory.

L. Boxes and Cabinets:

1. Outlet boxes:

a. UL 514A, capable of accommodating conduit as shown.

b. Material and finish:

1) Steel, malleable iron, cast iron or ductile iron.

2) Pre-galvanized sheet steel

3) Stainless steel in station public areas, if surface mounted.

c. For above ground indoor locations and electrical rooms: Punched or formed knockouts.

d. For wall receptacles and switches, single or double devices: Outlet boxes 4-11/16 square inches by 1-1/2 inch deep.

e. For floor receptacles: Watertight cast-iron outlet boxes, four inches diameter, of suitable depth and complete with the following:

1) Adjustment screws for final leveling.

2) Bronze floor plate with flush-mounted screw plugs, without exposed fastener, M32 finish.

3) Screw plug attached to outlet-box assembly by chain or other means, M32 finish.

4) Bronze floor plate flange, five inches in diameter, extending beyond box 1/2-inch above finished floor, M32 finish.

5) One special screw-plug removal tool with every 10 receptacles.

f. For recessed wall-mounted receptacles: Watertight cast- iron outlet box, three-inch diameter, of suitable depth and complete with the following:

1) Bronze faceplate with flush-mounted screw plug, without exposed fasteners, M32 finish.

2) Screw plug attached to outlet-box assembly by chain or other approved means, M32 finish.

3) Bronze faceplate flange, five inches in diameter, extending beyond box, M32 finish.

4) One special screw-plug removal tool with every 5 receptacles.

2. Junction and pull boxes:

a. Internal volume up to 100 cubic inches, metallic boxes: UL 514A, non-metallic boxes: UL514C; internal volume above 100 cubic inches, UL 50.

b. Flush-mounted or surface-mounted as shown.

c. Size: Suitable to accommodate conduit, raceways, ducts, number of cables and splices shown.

d. Material and finish:

1) Metallic boxes:

a) Steel, malleable iron, cast iron or ductile iron.

b) Pre-galvanized sheet steel

c) Stainless steel in station public areas.

2) Non-metallic boxes for locations outside of station:

a) Precast concrete: Compressive strength 3,500 psi; air entrainment six-percent minimum, ASTM C173-94ae1 or C231-97e1; Section 03 30 00 and Section 03 41 00 and in accordance with the following:

i) Box: Concrete formed with closed bottom and sides and recess at top of box or at edge of cover to provide mating surfaces to prevent lateral movement of flush-mounted cover. Knockouts provided to accommodate conduits as shown.

ii) Cover:

(a) Material same as for box. Use of metallic cover and cover frame prohibited.

(b) Metro Type "B" logo with 3 1/8 inch by 4 inch envelope and service designation recessed in center of cover.

(c) Non-protruding provisions provided for lifting.

iii) Reinforcement:

(a) Sidewalk and landscape locations: Welded wire fabric, ASTM A185-97.

(b) Areas subject to vehicular traffic: Deformed steel bars, ASTM A615/A615M-00.

iv) Loading:

(a) Sidewalk and landscape locations: AASHTO's SSHB H15- 44.

(b) Areas subject to vehicular traffic: AASHTO's SSHB H20-44.

(c) Hardware: Stainless steel.

v) Size: As shown or next available larger size.

b) Composite material: Sand and gravel bound together with a polymer and reinforced with continuous woven glass strands and in accordance with the following:

Physical Properties	Values	Method
Compressive strength	11,000 psi	ASTM C109
Tensile strength	1,700 psi	ASTM D638
Flexural strength	7,500 psi	ASTM D790
Water Absorption (24 hours)	0.5 percent	ASTM D570

i) Box: Gray-color material formed with closed bottom and sides and flange with recess at top of box to accommodate flush-mounted cover.

ii) Cover:

(a) Material same as for box.

(b) Skid-resistant top surface with minimum 0.5 coefficient of friction.

(c) Metro Type "B" logo with 3-1/8 inch by 4-inch envelope and service designation recessed in center of cover.

(d) Secured to box with bolts.

(e) Non-protruding provisions provided for

lifting.

iii) Loading:

(a) Sidewalk and landscape locations: AASHTO's SSHB H15- 44.

(b) Areas subject to vehicular traffic: AASHTO's SSHB H20-44.

iv) Hardware: Stainless steel.

v) Size: As shown or next available larger size.

c) Molded fiberglass-reinforced polyester 1/8-inch thickness, minimum, and in accordance with the following requirements:

Physical Properties	Values	Method
Flexural strength	17,000 psi	ASTM D790
Deflection temperature	400F	ASTM D648
Water absorption (24 hours)	0.5 percent	ASTM D570
Tensile strength	6,500 psi	ASTM D638
Specific gravity	1.8	ASTM D794
Flammability	94-5V	UL 94
Dielectric strength	400 Volts per mil	ASTM D149
Arc resistance	180 seconds	ASTM D495

i) Ultraviolet protection: Fiberglass material containing ultraviolet-inhibitor, or coated with polyurethane paint, 1.5 mils minimum dry-film thickness on both inside and outside surfaces.

ii) Color: Fiberglass material, gray inside and outside.

d) Molded polyvinyl chloride 1/8-inch thickness, minimum.

e. For aboveground indoor locations and electrical rooms: Punched or formed knockouts.

3. Cabinets:

a. UL 50, fabricated from galvanized steel.

b. Surface-mounted, unless otherwise shown.

c. Back plate of reinforced steel for mounting interior components and to ensure rigid support and accurate alignment.

d. Provision for cabinet grounding.

e. Provide latch and handle in accordance with UL 50; screw fastenings will not be accepted in lieu of latch.

f. Finish: Metallic surface thoroughly cleaned, degreased, primed with zinc primer and coated after fabrication with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.

M. Cable Trays:

1. NEMA VE1, ventilated-steel ladder-type.

2. Dimensions: Three inches inside depth; nine inches rang spacing unless otherwise shown.

3. Maximum load rating: The more stringent of 50 pounds per linear foot with safety factor of 1.5 at 12-foot support.

4. Bend radius:

a. For incoming service cable: As required by power company.

b. For all other cable: 24 inches or as necessary and approved.

5. Finish: Cable trays, fittings and accessories hot-dip galvanized or electro galvanized after fabrication.

N. Expansion Bolt Anchors: FS FF-S-325C Group II, stainless steel, Type 304.

1. Not Permitted: vertical loads in continuous tension.

2. Use stainless steel undercut anchors for vertical loads in continuous tension.

O. Fiberglass Conduit and Fittings:

1. Rigid fiberglass reinforced epoxy conduit, UL 1684, IPS (Iron Pipe Size) based conduit.

2. Conduit shall be manufactured by using filament winding process with minimum fiberglass content of 65 percent by weight and no fillers.

3. IPS based conduit with nominal wall thickness of 0.09 inches for five inch nominal conduit size.

4. Conduits, elbows and fittings manufactured from the same material and using the same manufacturing process.

5. Conduit sections formed with integral bell and spigot type couplings. Rubber sealing gasket at bell end is prohibited.

6. Conduits, elbows and fittings provided with protection from exposure to sunlight by pigmentation uniformly dispersed through resin material.

7. Adhesive as recommended by conduit manufacturer.

8. Conduits, elbows and fittings are specified for use throughout a temperature range of -40°F to 230°F, and they are to be protected from exposure to sunlight by pigmentation uniformly dispersed through the resin material.

9. Conduits, elbows and fittings shall be suitable for encasement in concrete below grade and conform to UL 1684, and listed and labeled by UL meeting the requirements of NEC Article 344 for Rigid Nonmetallic Conduit and its use.

10. Each piece of the straight length conduit and each piece of the elbow and other bend made from and for use with such conduit is to be labeled with the following information, mark clearly legible and durable every 10 feet or as recommended by the manufacturer.

    a. "Reinforced Thermosetting Resin Conduit", "RTRC"; "Fiberglass Reinforced Epoxy Conduit", "FREC"; or equivalent, as applicable.

    b. Normal Size: (IPS)

    c. Manufacturer's name and trademark.

    d. Temperature range for conduit application.

    e. "Above Ground", "AG", "Below Ground", "BG", or equivalent wording, as applicable.

PART 3 – EXECUTION

3.1 INSTALLATION

A. General:

1. Use size, type, general routing, and location of conduit, raceways, boxes and cabinets as shown and specified.

2. Install metallic raceway, fittings, boxes and cabinets free from contact with reinforcing steel.

3. Make metallic conduit, raceways, ducts and cable trays, electrically and mechanically continuous and ground them in accordance with Section 16060,

4. Where aluminum is placed in contact with dissimilar metal or with concrete, separate contact surfaces by means of gasket, non- absorptive tape or coating to prevent corrosion.

5. For Passenger Stations and facilities work:

    a. Install FRE conduits where conduit runs are embedded in concrete and where conduit is shown as direct-burial.

    b. On mezzanine level, for conduit runs to map cases, etc. use underfloor duct and fittings unless shown otherwise.

B. Conduit:

1. Run exposed conduit parallel to building lines.

2. Install exposed conduit to avoid interference with other work.

3. Traction-power substations, tie-breaker stations, electrical, mechanical rooms, train-control and communication rooms: Where shown or where necessary to prevent seepage of subsoil or water into such areas, seal where conduits are in contact with concrete, seal cable inside conduit using cable seal or sealing compound in accordance with the following requirements:

    a. Where shown and as necessary, install cable seal and conduit seal in

accordance with the manufacturer's recommendations.

b. Use sealing compound where approved and in accordance with manufacturer's recommendations, with the following additional requirements:

1) Before applying sealing compound, prime concrete, conduit and cable surface using primer recommended by manufacturer.

2) Pour or inject compound to prevent voids inside seal and to keep cable centered in conduit.

3) Use FRE sleeve for conduit seal installed on traction- power, train-control and communication conduit.

c. In empty conduit installed for future use, install blank cable seal inside conduit to prevent seepage of water.

d. All conduits shall be free of water before conduit seals are installed.

4. Apply lead-free conductive anti-seize compound to threaded-conduit joints.

5. In aboveground indoor locations and electrical rooms, use locknut and nylon-insulated bushing to attach conduit to enclosure.

6. Install suitable caps or plugs in empty conduit for future extension. Leave approved nylon or polyester pull line in each conduit.

7. Thread and ream ends of field-cut conduit to remove rough edges. Use bushing at conduit entrance to boxes, cabinets and equipment enclosures.

8. Bends:

a. Unless otherwise shown or specified, install conduit bends in accordance with reference codes.

b. Install bends in buried conduit in accordance with the following:

Size of Conduit (in inches)	Minimum Radius of Factory-Bend (in inches)	Minimum Radius of Field-Bend (in inches)
3	18	24
4	24	30
5	48	48
6	48	48

c. Total bends in each conduit run for traction-power cable: 225 degrees maximum.

d. Bend conduit so that field-made bend is free from cuts, dents and other surface damage.

9. Support conduit during construction to prevent distortion and to ensure independent support.

10. Support horizontal conduit with one-hole pipe straps or individual pipe hangers.

11. Secure conduit supported on multiple-hangers (trapeze) or channel inserts by fasteners suitable for such purpose.

12. Where conduit is attached to masonry surface, use malleable-iron spacers with Style A pipe straps.

13. Support and secure vertical conduit spanning open areas at intervals not exceeding 10 feet.

14. Support conduit above suspended ceiling using applicable specified methods.

15. Install conduit so as to drain moisture to nearest outlet or pull box.

16. Use minimum of 18-inch long liquid-tight flexible-conduit connection for equipment enclosure subject to vibration.

17. Do not use wire for support of conduit and cable.

18. Install expansion fitting in exposed conduit runs longer than 300 feet and where shown. Install expansion/deflection fittings where embedded conduits cross structural expansion joints. Where embedded conduits cross a structural contraction joint, paint the external surface of conduit with linseed oil or other compatible bond breaker for two feet on each side of contraction joint.

19. Use metallic conduit or above ground FRE conduit in exposed locations.

20. In addition to conduit installation requirements herein perform work at Passenger Stations and facilities and where shown as follows:

    a. In outdoor and underground locations, except electrical rooms, use threaded-conduit hub to attach conduit to equipment enclosure. Use watertight conduit fitting with gasket, nylon-insulated throat and sealing locknuts for attachment of conduit to enclosure having punched or formed knockout.

    b. Install suitable caps or plugs in empty conduit for future extension. Leave approved nylon or polyester pull line in each conduit.

    c. Buried FRE conduit: Install in accordance with the following requirements in addition to those specified elsewhere:

        1) Arrange conduit to cross each expansion joint at right angle to joint.

        2) Prevent concrete and other materials from obstructing the conduit. Pack outlets, pull boxes and junction boxes and cap conduit ends prior to pouring concrete.

        3) Use Tight Lock Joint method to join conduit sections for providing water tightness and pull out strength.

        4) Provide compatible conduit supports and spacers to maintain position of conduit during placement of concrete.

        5) Install buried non-metallic conduit for cable over 600 Volts in accordance with reference code.

6) Waterproof conduit connections.

7) Rod and swab conduit after installation so as to remove water, cement and other foreign matter; cap conduit ends. If obstructions cannot be removed or if condition exists which may result in damage to cable, replace conduit.

8) Leave approved nylon or polyester pull-line in each conduit.

d. Conduit installed in outdoor location: Waterproof conduit connection.

e. Use IPS FRE conduit for all concrete-encased applications except as follows:

1) Use FRE conduit with minimum wall thickness of 0.95 inch for train control conduit direct buried without concrete encasement where shown.

2) Install conduits encased in concrete duct banks, associated manholes and handholes outside the structural work in accordance with Section 33 71 19 and 33 81 26.

C. Channel Inserts and Spot Inserts:

1. Surface-mount channel inserts as shown.

D. Surface Raceways:

1. Install as shown.

E. Underfloor Raceways:

1. Install underfloor raceways as specified in Section 03 10 00. Align and level raceways accurately. Hold raceways in place during placing of concrete.

F. Outlet, Junction and Pull Boxes:

1. Mount outlet boxes as shown.

2. Arrange front of box or attached plaster cover flush with finished wall or ceiling.

3. Keep number of knock-outs to minimum.

4. Clean boxes thoroughly after installation and correct damage to boxes and to finish.

5. Install covers on boxes mounted on walls and ceilings.

6. Measure height of wall-mounted outlet box from finished floor to horizontal centerline of cover plate.

7. Fasten floor boxes securely in place.

8. Install junction and pull boxes so that covers are readily accessible.

9. Do not install boxes above suspended ceilings except where ceilings are removable or definite provision is made for access to boxes.

10. Use non-metallic boxes as follows:

a. Buried with cover flush-mounted with finish grade: Precast concrete or composite material junction and pull boxes within AASHTO load designations as specified.

b. For indoor and outdoor locations not subject to pedestrian or vehicular traffic: Molded fiberglass-reinforced polyester junction and pull boxes.

c. For outdoor locations but not for burial: Molded polyvinyl chloride junction and pull boxes.

11. In addition to the Outlet, Junction and Pullbox installation requirements herein perform work at Passenger Station and Facilities and where shown as follows:

a. Use stainless steel (Type 304) mounting channels, retaining straps and fasteners, pipe hangers, expansion bolt/anchors for mounting of conduits, cables, junction boxes, outlet boxes and enclosures

b. Use stainless steel type 304 cover plates for receptacles.

G. Cabinets:

1. Fasten cabinet securely using expansion bolts, toggle bolts or mounting ears.

2. Touch-up damaged painted finish.

H. Cable Trays:

1. Install cable trays neatly, adequately supported and as shown.

2. For incoming-service cable from Power Company, install cable tray as approved by the power company.

I. Use expansion-bolt anchors to secure equipment to concrete surfaces.

J. Attachments to Prestressed-Concrete Girders:

1. Attach pipes, conduits, boxes or similar items to prestressed girders by welding to embedded plates or bolting to embedded fittings. Drilling into prestressed girders is prohibited, except for track fasteners and appurtenances as shown.

3.2 FILLING OF OPENINGS

A. Where conduit and raceway pass through fire-rated walls, ceilings or floors, provide UL rated sealing system to prevent passage of fire and fumes and to maintain integrity of fire-rated structure.

B. Where openings are provided for passage of conduit and raceways in walls, ceilings or floors, use UL rated fire-resistant fibrous-glass safing or similar material to seal unused openings to prevent passage of fire and fumes.

C. Close unused openings or spaces in floors, walls and ceilings. Plug or cap unused conduit and sleeves.

3.3 IDENTIFICATION

A. At end of each run, use stainless steel or aluminum tags, minimum 1-½- inch diameter, with stamped markings, minimum ¼-inch high lettering, and tag holders attached to conduit using a stainless steel band with worm screw clamping device to establish identification of conduits and raceways in accordance with designations shown. Where conduits are terminated flush with concrete structure, install three-ply laminated phenolic plate, engraved through black face to white core and attached adjacent to conduits' entrance by means of non-metallic screws. Engrave conduits' designations within circles arranged in pattern similar to that of conduits.

B. Identify by red painted color code and by marking EMERGENCY SYSTEM on all boxes and enclosures for emergency circuits to identify them as part of an emergency system in accordance with the NEC.

3.4 FIELD QUALITY CONTROL

A. Refer to the Contract Documents.

1. Submit test procedures in accordance with the Contract Documents and Section 01 79 00 for approval and perform approved tests. Do not perform tests without approved test procedure. Furnish the equipment, personnel to perform the following tests:

B. Arrange with the Installer for inspection and approval of embedded conduit and boxes prior to concrete placement.

C. Arrange with the Installer for inspection of incoming-service conduit prior to placing concrete in accordance with the Contract Documents.

D. Test metallic conduit and boxes for electrical continuity. Conduct tests in accordance with the contract requirements.

E. Arrange for inspection and approval of direct-buried conduits for future train control circuits prior to backfilling.

F. At Passenger Stations and Facilities perform the pullout-load rating test as follows:

1. Test not less than 0.5 percent of total installed channel inserts and spot inserts as directed for compliance with specified pullout-load rating. Replace and retest inserts which fail. Conduct tests in presence of the Contractor.

END OF SECTION

SECTION 16145

WIRING AND CONTROL DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION:

A. This section specifies providing switches, cover plates, limit switches, occupancy sensors, receptacles, plugs, magnetic contactors, automatic transfer switches, photoelectric controls and time switches.

B. Related Work Specified Elsewhere:
1. Ornamental metal: Section 05700.
2. Wire connection accessories: Section 16125.
3. Grounding and bonding: Section 16060.
4. Raceways, boxes and cabinets: Section 16130.

1.2 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. National Electrical Code (NEC).
3. National Electrical Manufacturers Association (NEMA):WD1, General Color Requirements for Wiring Devices*;* KS1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum); ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC; ICS 12, Profiles of Networked Industrial Devices--Part 1: General Rules; NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
4. American National Standards Institute (ANSI): Z55.1, Gray Finishes for Industrial Apparatus and Equipment.
5. UL: 98, Enclosed and Dead-Front Switches; 198D, Class K Fuses; 198E, Class R Fuses; 508, Industrial Control Equipment; 773, Plug-In Locking-Type Photo controls for Use With Area Lighting; 1008, Transfer Switch Equipment.
6. American Standards of Testing and Materials (ASTM): A47/A47M-99, Standard Specification for Ferritic Malleable Iron Castings; A276-00a, Standard Specification for Stainless Steel Bars and Shapes; and A507-00, Standard Specification for Drawing Alloy Steel, Sheet and Strip, Hot-Rolled and Cold-Rolled.
7. ITS: Directory of ITS Listed Products

B. Source Quality Control:
1. Following items listed per referenced UL or ITS directory:
   a. Snap switches.
   b. Disconnect switches.
   c. Receptacles and plugs.
   d. Automatic transfer switch.
   e. Lighting contactor.
   f. Photoelectric control.
   g. Time switch.
   h. Occupancy sensor.

C. Qualifications: Select a manufacturer who is regularly engaged in the production of automatic transfer switches.

1.3 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

1. Shop Drawings.
2. Certification:
   a. Certified test reports of factory tests performed on each automatic transfer-switch unit in accordance with reference standards.
   b. Furnish certificate from manufacturer verifying that automatic transfer switches conform to specified requirements. Include certificate with submittal of shop drawings.
3. Documentation for Automatic Transfer Switch:
   a. Submit field test plan within 60 days after award with accompanying documentation in the form of test data recording sheets and list of proposed test equipment for approval prior to testing.
   b. Submit certified copies of test data, dated and clearly identified within two weeks after completion of testing.
4. Operation and Maintenance Manuals for Automatic Transfer Switch.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Mark each item in accordance with applicable reference standard.

B. Ship each unit securely packaged and labeled for safe handling and to avoid damage

C. Store products in secure and dry storage facility.

PART 2 - PRODUCTS

2.1 PRODUCTS AND MATERIALS:

A. Snap Switches:
1. NEMA WD1, specification grade.
2. Rating:
   a. Twenty amperes at 120-277 volts ac.
   b. Horsepower-rated when used as disconnecting device for motor circuit.
3. Body and base: Fully enclosed, brown, fire-resistant, non-absorptive thermosetting urea or nylon.
4. Contacts: Silver alloy.
5. Mounting yoke: Corrosion-resistant metal with plaster ears.
6. Poles: Single-pole, double-pole, three-way or four-way as shown.

B. Disconnect (Safety) Switches:
1. UL 98, NEMA KS1, heavy-duty, fusible or non-fusible as shown.
2. Voltage rating: 240 volts ac, 480 volts ac or 250 volts dc as shown and as necessary.
3. Number of poles and current rating: As shown and as necessary.
4. Fuses:
   a. UL 198D.

b. For fused disconnect switch associated with motor load: UL Class RK5 with time delay or as shown.
c. For fused disconnect switch associated with other loads: UL Class RK1 or as shown.
d. Current rating: As shown.

5. Enclosure: (NEMA 250)
   a. Type:
      1) For aboveground indoor locations and electrical rooms: Type 1.
      2) For tunnel and underground locations, except electrical rooms: Type 4.
      3) For outdoor locations: Type 3R.
   b. Materials:
      1) Steel sheet: ASTM A507-00.
      2) Malleable iron: ASTM A47/A47M-99.
   c. Finish: Metallic surface cleaned, degreased, primed with zinc primer and finished with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.
6. Quick-make/quick-break switching mechanism with operating handle external to enclosure with positions labeled ON/OFF and capable of being padlocked in OFF position, defeatable interlock to prevent opening of enclosure door when switch is closed.

C. Receptacles and Plugs:
1. NEMA WD1, specification grade.
2. Rating: 20 amperes at 125 or 250 volts as shown.
3. Base and body: Brown, fire-resistant, non-absorptive thermosetting urea or nylon.
4. Receptacles:
   a. Outlet: Single or duplex as shown.
   b. Mounting yoke: Corrosion-resistant metal with plaster ears.
   c. Configuration:

Rating	NEMA Configuration
Two-pole, three-wire, 20 amps, 125 volts	5-20 R
Two-pole, three-wire, 20 amps, 250 volts	6-20 R

   d. For use in restroom; water service room; locker room; wash rooms; elevator machine room, pit and hoistway; and outdoor locations: Equipped with solid-state ground-fault circuit interrupter with five-milliamp ere trip level.

5. Plugs:
   a. Configuration and design: As follows unless otherwise shown:

Rating		NEMA Configuration
Two-pole, three-wire, 20 amps, 125 volts	Urea or neoprene with cord grip	5-20 P
Two-pole, three-wire, 20 amps, 250 volts	Armored cap with cord grip	6-20 P

D. Cover Plates:
   1. Wall plates:
      a. NEMA WD1, suitable for specified receptacles and switches, size suitable for recess-mounted or surface-mounted associated outlet box, stainless steel, ASTM A276-00a, Type 304, or approved equal.
      b. For use in indoor public areas: Bronze, with M32 medium satin finish as specified in Section 05700.
      c. For above ground indoor service areas and electrical rooms: Steel, stainless steel or aluminum plate, as standard with the manufacturer.
      d. For receptacles in outdoor and underground locations, except electrical rooms: Stainless steel, ASTM A276-00a, Type 304, wall plate with gasketed spring-loaded hinged cover.
   2. Floor plates: Section 16130.

E. Automatic transfer switch: UL-1008, electromechanical, in surface-mounted enclosure as shown, with the following additional requirements:
   1. Operating and electrical characteristics:
      a. Capable of transferring load automatically from normal source to alternate source when the voltage drops to 85 percent of rated voltage on any phase for set time. Operating point adjustable over range of 80 to 90 percent of rated voltage and time-delay adjustable over range from zero to five minutes in increments of at least eight steps.
      b. Capable of transferring load automatically from alternate source to normal source when normal source returns to 90 percent of rated voltage for set time. Operating point adjustable over range of 85 to 100 percent of rated voltage and time-delay adjustable over range from zero to five minutes in increments of at least eight steps.
      c. Capable of transferring load automatically from normal source to alternate source when normal source failure is simulated by integral test switch.
      d. Rating:
         1) Number of poles: Three or four as shown.
         2) Voltage rating: 480-volt, three-phase, three-wire or 480Y/277-volt, three-phase, four-wire, 60 Hertz system as shown.
         3) Current rating: As shown and rated 100 percent.
         4) Transfer time: Ten cycles maximum on 60-Hertz base after initiation signal.
         5) Short-circuit current rating, rms symmetrical amperes: 14,000; 22,000; 25,000; 30,000; 35,000; or 50,000 as required and shown.
         6) Capacity to close into available short-circuit current or let-through current of fuses without functional degrading.

e. Solid-state control panel for sensing and control logic with accuracy of plus-or-minus two percent on voltage and frequency settings over a temperature range of minus 20 degrees to plus 70 degrees.

2. Design and construction features:
   a. Mechanically held, electrically operated, double-throw switch.
   b. Electrical and mechanical interlock to prevent maintained neutral position.
   c. Designed to break-before-make on transfer and retransfer.
   d. Equipped with renewable silver-alloy contact.
   e. Neutral bus or terminal provided on 480Y/277-volt, three-phase, four-wire unit to allow interconnection of neutral conductors.
   f. Pilot lights on door to indicate switch position as follows:
      1) On normal source: Green light.
      2) On alternate source: Red light.
   g. Pilot lights on door to indicate:
      1) Normal source available: Green or white light.
      2) Alternate source available: Red or white light.
   h. Contacts opened by single solenoid, motor operator or stored energy mechanism.
   i. Handle provided to permit manual operation of automatic transfer switch for maintenance purposes.
   j. Power conductors made of silver-plated copper bus.
   k. Equipment ground lug provided.
3. Enclosure:
   a. Type:
      1) For aboveground indoor locations and electrical rooms: NEMA Type1.
      2) For tunnel and underground locations, except electrical rooms: NEMA Type 12.
   b. Door: Hinged with handle and latch.
   c. Material: Steel.
   d. Finish: Metallic surface thoroughly cleaned, degreased, primed with zinc primer and finished with gray enamel, ANSI Z55.1, Color No. 61; two mils minimum DFT.

F. Lighting Contactors:
1. NEMA ICS 2, UL 508, electrically held, equipped with silver-alloy contacts, designed to control incandescent, tungsten, halogen, fluorescent, high-intensity discharge lamp load.
2. Number of poles: As shown.
3. Continuous current rating: As shown.
4. Line and load voltage: 480-volt or 208-volt three-phase or 277-volt or 120-volt single-phase as shown.
5. Control coil rated 120 volts.
6. 480-volt or 277-volt to 120-volt control transformer fused on secondary and primary as required.
7. Control:
   a. Heavy-duty, three-position selector switch with positions labeled HAND/OFF/AUTO for lights controlled by photo-electric cell.
   b. ON-OFF push button for indoor lights.
8. Enclosure: NEMA 250, Type 1; fabricated from steel, cleaned, degreased, primed with zinc primer and finished with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.

G. Photoelectric Control:

1. UL 773, designed to respond to natural daylight with 15-second inherent delay to prevent functioning due to sudden bright light such as vehicle lights or lightning and to operate in ambient temperature from minus 50C to plus 60C.
2. Adjust to turn lights ON at two plus-or-minus one foot-candles, unless otherwise specified. ON to OFF ratio: One to three.
3. Rating: 1,800VA at 120 volts or 277 volts, 60 Hertz, as shown.
4. Contacts:
   a. For control of outdoor lights: SPST, NC contact.
   b. For control of tunnel lights at portals: SPST, NO contact
5. Cells: Hermetically sealed.
6. Enclosure: Weatherproof and tamper proof aluminum or non-metallic enclosure equipped with locking receptacles when mounted on fixture or designed for mounting on outlet box as shown and as necessary.
7. At tunnel portal, set photoelectric control to turn on selected lights at dawn and turn off lights at dusk, as shown.

H. Limit Switches:
1. NEMA ICS 2, industrial-control.
2. Suitable for mounting in folding-gate cabinet. Switch contacts closed when cabinet door is fully closed and latched. Switch contacts opened when respective cabinet door is not fully closed.
3. Voltage rating: 120 volts ac.
4. Current rating: 10-amperes continuous.
5. Enclosure: NEMA 250, Type 13.
6. Actuator: Lever-operated and adjustable, with spring return.
7. Mounting: Plug-in type with receptacle tapped for conduit size as shown.
8. Contacts: Single-pole double-throw; one NO, one NC; snap action.

I. Time Switch:
1. Seven-day and 24-hour calibration for each day time switch, listed per referenced UL or ITS directory, heavy-duty type suitable for controlling type of lighting fixtures shown.
2. Type: As shown, with contacts capable of switching continuous load of 20 or 40 amperes per pole at 277 volts as necessary.
3. Seven-day, 24-hour dial with day and night zones and 24-hour calibration for each hour clearly marked.
4. Providing up to four automatic ON/OFF operations each day.
5. Removable ON/OFF trippers designed for minimum ON period of one hour and minimum two-hour period between one OFF operation and next ON operation.
6. Provision for manual ON and OFF operation of switch by hand without disturbing weekly preset schedule.
7. Provision for omitting operation of switch on selected days.
8. Spring-driven reserve power suitable for operation of switch for 16 hours minimum after failure of power. On restoration of power, switch transfers to synchronous motor drive and automatically rewinds spring.
9. Terminals designed to accommodate up to 8AWG conductor cable.
10. Operation at 480/277Y or 208Y/120 volts, 60 Hertz as shown and within temperature range of zero degree F to plus 140F.
11. Enclosure:
    a. NEMA 250, Type 1, steel, surface-mounted.
    b. Hinged flush front door with catches and spring-loaded door pull.
    c. Finish: Metallic surfaces cleaned and degreased, primed with zinc primer and finished with one coat of light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.

J. Occupancy Sensor:
1. UL 508, passive infra-red motion detector designed for wall mounting over single-gang outlet box, minimum radio frequency interference and use with incandescent and fluorescent lighting fixtures and electronic ballasts.
2. Voltage rating: 120-277 volts ac.
3. Switching capacity:
   a. 120-volt operation: 800 watts minimum.
   b. 277-volt operation: 1,500 watts minimum.
4. Coverage area: 1,000 square feet.
5. Detection zone:
   a. Horizontal: 180 degrees.
   b. Vertical: 5 degrees.
6. Ambient light sensing: Photocell for preventing operation of lights at ambient light levels above an adjustable setting.
7. Adjustments: Adjustable settings for time delay, sensitivity and light level concealed by tamper proof cover. Time delay adjustable from 10 seconds to 15 minutes after motion stops.
8. Operating mode: OFF/AUTO.
9. Detection indicator: LED.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Install switches, limit switches, occupancy sensors, receptacles, automatic transfer switches, lighting contactor, photoelectric controls and time switches as shown and in accordance with referenced codes and standards in Article 1.2, and manufacturer's instructions.

B. Install cover plate on switch and receptacle.

C. Install cover plate with gasketed spring-loaded cover, on each receptacle in outdoor and underground locations except electrical rooms.

D. Grounds disconnect switch, time switches, automatic transfer switches, receptacles, snap switches, photoelectric controls and lighting-contact or enclosures in accordance with Section 16060.

E. Make power cable connections to snap switches, plugs, time switches, occupancy sensors, photoelectric controls, receptacles, automatic transfer switches and lighting contactors by means of integral mechanical connectors. If such items are not furnished with integral mechanical connectors, make connections using compression connectors in accordance with Section 16125.

F. Make power cable connections to snap switches and receptacles using their side screw wiring connection terminals.

G. Apply matching touch-up paint as necessary.

3.2 FIELD QUALITY CONTROL:

A. Furnish necessary test equipment and perform the following in the presence of the Engineer, in accordance with approved procedures:
   1. Test time switches, receptacles and contactors for connection in accordance with wiring diagram.
   2. Test equipment enclosure for continuity to grounding system.
   3. Check tightness of cable connections of snap switches, receptacles, time switches, occupancy sensors, disconnect switches, automatic transfer switches, lighting contactors, photoelectric controls and limit switches.
   4. Test operations of circuits and controls of switches, occupancy sensors, receptacles and contactors.
   5. Automatic transfer switches:
      a. Test switches for connection in accordance with wiring diagrams.
      b. Calibrate and set voltage-sensing device for each source and time delay for transfer and retransfer as follows and as approved:
         1) Automatic transfer switches for fan shafts and drainage pumping stations: Time delay setting for transfer equal to total of 30 seconds for each connected motor or additional time as required.
         2) Time delay setting for retransfers equal to or greater than time delay setting for transfer.
      c. Perform automatic transfer of load in accordance with the following requirements:
         1) With power available on both the normal and alternate sources, initiate automatic transfer from the normal source to the alternate source by opening the disconnect switch or circuit breaker on the line side of the automatic transfer switch for the normal source. Check that the switch position changes to the alternate source and remains connected to the alternate source.
         2) With power available on the alternate source and the switch connected to the alternate source, initiate automatic transfer to the normal source by closing the disconnect switch or circuit breaker on the line side of the automatic transfer switch for the normal source. Check that the switch position changes to the normal source and remains connected to the normal source.
         3) If testing indicates failure to comply with specified requirements, modify settings for the automatic transfer switch so that the specified requirements are met. Conduct additional tests witnessed by the Engineer to prove compliance with specified requirements.

B. Submit certified test reports for compliance with field quality control requirements.

END OF SECTION

SECTION 16225

MOTORS

PART 1 - GENERAL

1.1 DESCRIPTIONS:

A. This section specifies providing motors.

B. Related Work Specified Elsewhere:
   1. Grounding and bonding: Section 16060.
   2. Wire connection accessories: Section 16125.
   3. Raceways, boxes and cabinets: Section 16130.

1.2 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of jurisdictional authorities.
   2. NEC.
   3. IEEE: 85, 112.
   4. NEMA: MG1.
   5. ANSI: Z55.1.
   6. ASTM: A582.
   7. OSHA: 1910.95.

1.3 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Shop Drawings:
      a. Outline dimensions.
      b. Cross section showing internal construction and weight.
      c. Connection diagram.
   2. Certification.
   3. Operation and Maintenance Manuals.

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Ship each motor securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.

B. Store motors in secure and dry storage facility.

PART 2 - PRODUCTS

2.1 PRODUCTS AND MATERIALS:

A. Motors:
   1. NEMA MG1, squirrel-cage, induction-type, unless otherwise shown.
   2. Rating:

a. Horsepower: As shown.
b. Voltage and frequency:
   1) Motors, 1/2 HP and smaller: 115-volt, single-phase, 60 Hertz.
   2) Above 1/2 HP: 460-volt, three-phase, 60 Hertz, unless otherwise specified or shown.
   3) For motors in air-conditioning units:
      a) For units up to and including 10,000 BTUH: 115-volt, single-phase, 60 Hertz.
      b) For units from over 10,000 BTUH up to and including 36,000 BTUH: 208-volt, single-phase, 60 Hertz.
      c) For units over 36,000 BTUH: 460-volt, three-phase, 60 Hertz.
c. RPM: As shown.
d. Time rating: Continuous, unless otherwise shown.
e. Nominal full-load efficiency: Premium Efficiency when tested in accordance with NEMA MG1 and IEEE 112.

3. Design:
   a. Single-phase motors: Design N, suitable for full-voltage across-the-line starting.
   b. Three-phase motors: Design B, unless otherwise shown, with the following additional requirements:
      1) Up to and including 50-HP motors: Suitable for full-voltage across-the-line starting.
      2) Above 50-HP motors: Suitable for reduced-voltage starting.
4. Service factor:
   a. Motors, one HP and smaller: In accordance with NEMA MG1.
   b. Above one-HP up to and including 200-HP motors: 1.15.
   c. Above 200-HP motors: 1.00.
5. Insulation: Class and allowable temperature rise above average ambient temperature of 30C and maximum ambient temperature of 40C as follows:
   a. Integral-horsepower motors:
      1) Drip proof motors: Class B insulation with Class B temperature rise.
      2) Totally enclosed motors: Class F insulation with Class B temperature rise, unless otherwise shown or specified.
   b. Fractional-horsepower motors: In accordance with NEMA MG1.
6. Noise level: NEMA MG1-12.49 but not to exceed requirements of OSHA 1910.95 when measured in accordance with IEEE 85.
7. Enclosure:
   a. Drip proof, fully guarded; totally enclosed fan-cooled guarded; or totally enclosed air-over as specified.
   b. Heavy-duty steel or cast-iron frame.
   c. End bell:
      1) Up to 10HP: With cast-iron or aluminum end bells.
      2) 10HP and above: With cast-iron end bells.
   d. Mounting: Foot-mounted on pad or adjustable pad, if necessary or as otherwise shown.
   e. Provision for grounding.
   f. Finish: Red-oxide zinc-chromate primer with finish coat of light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.
   g. Totally enclosed air-over:
      1) Variation to totally enclosed fan-cooled machines with air flow for cooling supplied by fan specified elsewhere.

2) Fan/motor application factory-engineered for air flow shown or specified.

8. Conduit box:
   a. Diagonally split, suitably gasketed.
   b. Type:
      1) Up to 10HP: Steel, cast iron or aluminum with threaded or punched conduit holes.
      2) 10HP and above: Cast iron with threaded conduit holes.
   c. Size suitable to accommodate motor and line leads including taping.
   d. Capable of rotation in each 90-degree position.
9. Bearings:
   a. Unless otherwise specified, average life 15 years, but not less than three years at continuous operation, with double shields.
   b. Integral-horsepower motors:
      1) Five HP and smaller: Sealed ball bearings or roller bearings.
      2) Above five HP: Ball bearings or roller bearings with grease fittings and pressure-relief fittings for in-service lubrication.
   c. Fractional-horsepower motors:
      1) 1/6 HP and larger: Sealed ball bearings.
      2) Below 1/6 HP: Sealed ball bearings or sleeve.
10. Motors for hermetically sealed and semi-hermetically sealed compressors: NEMA MG1, 18.076 through 18.093.
11. Motors for close-coupled pumps: Stainless-steel shaft in accordance with ASTM A582, Type 303.
12. Provide nameplate on each motor in accordance with NEMA MG1-10.37.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Install motors where shown and in accordance with the NEC.

B. Install conduit in accordance with Section 16130.

C. Connect power cable as shown and in accordance with Section 16125.

D. Ground motor enclosure in accordance with Section 16060.

3.2 FIELD QUALITY CONTROL:

A. Furnish necessary equipment and perform the following tests:
   1. Check and test wiring connections in accordance with wiring diagram.
   2. Test to ensure that insulation resistance of motor winding is 10 megohms minimum.
   3. Test motor enclosure for continuity to grounding system.
   4. Test motors for proper operation with their associated controls.

B. Submit certified test reports.

END OF SECTION

SECTION 16425
MOTOR STARTERS

PART 1 – GENERAL

1.1 DESCRIPTION

A. This section specifies work pertaining to motor starters.

1.2 QUALITY ASSURANCE

A. Codes, Regulations, Reference Standards and Specifications:

1. Comply with codes and regulations of the Authority Having Jurisdiction
2. National Electrical Code (NEC) 2014 Edition.
3. NEMA AB1, ICS-2, ICS-2.3, 250.
4. ANSI: Z55.1.
5. ASTM: A47/A47M-99/06, A653/A6 (3M-07), B187/B187M-06.
6. UL: 845, Electrical Construction Materials Directory
7. ITS: Directory of ITS Listed Products.
8. The equipment manufacturer shall maintain an ISO 9001 or ISO 9002 certification.
9. National Fire Protection Association (NFPA) 130, 2014 Edition.

B. The following items to be listed or labeled per referenced UL or ITS Directory.

1. Motor starter.
2. Combination starters.
3. Motor circuit protectors.

1.3 SUBMITTALS

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

1. Shop Drawings
   a. Interconnection wiring diagrams
2. Certification can be provided by the contractor/subcontractor
3. Operation and Maintenance Manuals
4. Test Procedures
5. Field test plan
6. Field Test Reports (per Section 3.02)
7. Operation and Maintenance Manuals

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Ship each unit securely packaged and labeled for safe handling in shipment and to avoid damage or distortion.

B. Store motor starters and in secure and dry storage facility.

1.05 COMMISSIONING

The Contractor shall coordinate and participate with the overall Commissioning activities in accordance with the Contract Documents.

PART 2 – PRODUCTS

2.1 PRODUCTS AND MATERIALS

A. General Requirements for Motor Starters:

1. Interchangeability: Equipment of same type, size, rating, functional characteristics and make is to be interchangeable.
2. NEMA ICS-2, AC General-Purpose, Class A.
3. Rating: Continuous-current rating suitable for associated motor as shown.
4. Type:
   a. Up to and including ½ HP: Manual starter operable on 120-volt, single-phase, 60 Hertz supply unless otherwise shown.
   b. From above ½ HP up to and including 50 HP: Across-the- line magnetic starter operable on 480-volt, three-phase, and 60 Hertz supply.
   c. Above 50 HP: Closed-transition autotransformer starter operable on 480-volt, three-phase, 60 Hertz supply.
5. Provide ground-fault protection with five-ampere pick-up in each motor starter for pumps in drainage-pumping stations.
6. Enclosure:
   a. Type:
      1) For aboveground indoor locations and electrical rooms: As shown on drawings.
      2) For outdoor locations: NEMA 250, Type 3R.
   b. Materials:
      1) Zinc-coated steel sheet: ASTM A653, coating designate on G90, minimum thickness 14 gauge.
      2) Malleable iron: ASTM A47.
   c. Finish: Metallic surface cleaned, degreased, primed with zinc primer and finished with light-gray enamel, ANSI Z55.1, Color 61; minimum dry-film thickness, two mils.

7. Nameplate:

   a. Nameplate provided on each motor starter in accordance with NEMA ICS, showing manufacturer's name and brand designation, the referenced standard, type, class and rating as applicable.

   b. Additional functional nameplates for each component as follows:

      1) Three-ply, laminated phenolic plates engraved through black face to white core and attached by means of stainless-steel rivets or screws.

      2) Lettering to be vertical gothic using a round or square cutter. V-shaped groove not acceptable.

      3) Each starter labeled with one-inch wide nameplate showing starter's designation and function in ½-inch high characters.

B. Manual Starters: Quick-make/quick-break toggle mechanism, manual-Reset thermal-overload device, position indicator showing ON/OFF/TRIPPED positions, red indicating light showing closed position.

C. Across-The-Line Magnetic Starter:
1. Reversing or non-reversing as shown.
2. NEMA size: As shown as, not smaller than NEMA 1.
3. 480-volt primary to 120-volt secondary control transformer with single pole circuit breaker in the primary circuit.
4. Manual-reset overload relay, one per phase, magnetic type or solid state.
5. Two NO contacts with provision for addition of two NO or NC contacts.

D. Autotransformer Starter:
1. Reversing or nonreversing closed-transition type as shown.
2. NEMA size: As shown.
3. Adjustable taps for 50, 65 and 80 percent of line voltage.
4. 480-volt primary to 120-volt secondary control transformer with single pole circuit breaker in primary circuit.
5. Manual-reset overload relay, one per phase. a.

   Magnetic type or solid state
6. One pneumatic adjustable timing relay.
7. Two NO contacts with provision for addition of two NO or NC Contacts.

E. Motor Circuit Protectors (MCP):

1. NEMA AB1, molded-case, quick-make/quick-break, mechanically trip-free switching mechanism with adjustable magnetic trip for instantaneous short-circuit protection.

2. Rating:
   a. Number of poles: Three.

   b. Continuous-current rating: As shown, not less than full-load current of motor.

c. Voltage: 480-volt, three-phase, 60 Hertz. d.

Interrupting rating: As shown.

e. Trip range: As necessary to provide maximum protection to associated motor.

3. Where shown or necessary, individually removable current limiter, internally mounted on load side of MCP, with the following additional requirements:

a. Limiter current rating and time-current limiting characteristics coordinated with time-current characteristics of MCP to provide the following:

1) Interruption by MCP under fault-current level up to interrupting capacity of MCP.

2) Interruption by current limiter in conjunction with the MCP of fault-current level above interrupting capacity of MCP.

3) Where necessary to protect associated motor starter. Limit fault-current below withstand capability of the starter.

4) Where necessary to protect associated motor-circuit conductors. Limit fault-current below withstand capability of cable insulation.

b. Current-limiter housing interlocked with MCP tripping mechanism so that breaker will trip upon removal of cover.

c. Equipped with common trip mechanism for tripping all poles simultaneously on blowing of current limiter to prevent single phasing.

d. Capable of interrupting minimum fault-current up to 100,000 rms symmetrical amperes at 480 volts ac.

F. Combination Starter:

1. NEMA ICS-2, rated 480 volts, three-phase, 60 Hertz.

2. Motor starter: Across-the-line magnetic or autotransformer starter as shown and specified.

3. One 480-volt, three-pole MCP or disconnect switch, fused or unfused as shown.

4. Externally mounted operating handle with position indicator showing ON/OFF/TRIPPED condition of MCP. Operating handle interlocked for preventing opening and closing of door when MCP is in ON position. Defeater provided to bypass interlock. Provision for padlocking in OFF position.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install circuit breakers and motor starters shown in accordance with manufacturer's recommendations, the NEC and Section 16225, as appropriate for the type of motor.

B. Install conduit in accordance with Section 16130 and the NEC.

C. Connect power cable and control wire as recommended by manufacturers and as follows:

1. Make power-cable and control-cable connections to circuit breakers, manual starters, across-the-line magnetic starters and autotransformer starters by means of integral mechanical connectors. If such items are not furnished with integral mechanical connectors, make connections using compression connectors in accordance with Section 16122.

D. Ground motor starters, circuit breakers, complete in accordance with Section 16060.

E. Apply touch-up paint as necessary.

3.2 TESTING

A. Furnish necessary equipment and perform the following tests:

1. Test circuits for continuity in accordance with wiring diagram.

2. Test to ensure that insulation resistance to ground of nongrounded conductor is in accordance with Section 16060.
3. Test equipment enclosures for continuity to grounding system.
4. Test operation of circuits and controls. B.

Submit certified test reports.

END OF SECTION

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SECTION 16440

CIRCUIT BREAKERS, PANELBOARDS, AND LOAD CENTERS

PART 1 – GENERAL

1.1 DESCRIPTION

A. This section specifies work pertaining to circuit breakers, panelboards and load centers.

1.2 QUALITY ASSURANCE

A. Codes, Regulations, Reference Standards and Specifications:

1. Comply with Codes and regulations of Authority Having Jurisdiction.
2. National Electrical Code (NEC) 2014 Edition. 3.NEMA:

AB1, PB1, ST20, 250.

4. ANSI: Z55.1.
5. UL: 50, 67, 198C, 489, 891, Electrical Construction Materials Directory.
6. ASTM: A276-06, B187/B187M-06.
7. ITS: Directory of ITS Listed Products.
8. The equipment manufacturer shall maintain ISO 9001 or 9002 certification.
9. National Fire Protection Association (NFPA) 130, 2014

B. Source Quality Control:

1. Each item listed per referenced UL or ITS directory.

1.3 SUBMITTALS

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

1. Shop Drawings.
2. Certification can be provided by the contractor/subcontractor
3. Test procedures
4. Test reports
5. Operation and Maintenance Manuals

1.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Mark each circuit breaker, panelboard and transformer in accordance with applicable reference standard.

B. Ship each unit securely packaged and labeled for safe handling and to avoid damage or distortion.

C. Store products in secure and dry storage facility.

PART 2 – PRODUCTS

2.1 PRODUCTS AND MATERIALS

A. General Requirements:

1. Interchangeability: Components of the same type, size, rating, functional characteristics and make are to be interchangeable.

2. Finish for enclosures for enclosed circuit breakers, panelboards, emergency-service panelboards and load centers:

   a. Clean and degrease metallic surfaces.

   b. Prime with zinc primer.

   c. Finish with one coat of light-gray enamel, ANSI Z55.1, Color 61. Minimum dry-film thickness: Two mils.

B. Circuit Breaker: NEMA AB1, UL 489, molded-case, bolt-on, quick- make/quick-break, mechanically trip-free switching mechanism, with thermal trip for inverse time-delay overcurrent protection and magnetic trip for instantaneous short-circuit protection. Shunt-trip device for tripping by ground-fault relay as shown. Frame size 225 amperes and above equipped with interchangeable thermal trip and adjustable magnetic-trip unit. Designed to carry continuous rating in ambient temperature of 40 degrees Celsius with the following parameters as shown:

1. Number of poles.

2. Rated voltage.

3. Rated interrupting current.

4. Trip setting.

5. Frame size.

C. Circuit Breaker: NEMA AB1, UL 489, molded-case, bolt-on, quick- make/quick-break, mechanically trip-free switching mechanism, with magnetic trip only for instantaneous short-circuit protection. Shunt-trip device for tripping by ground-fault relay as shown. Frame size 225 amperes and above equipped with adjustable magnetic-trip unit. Designed to carry continuous rating in ambient temperature of 40 degrees Celsius with the following parameters as shown:

1. Number of poles.

2. Rated voltage.
3. Rated interrupting current.
4. Trip setting.
5. Frame size.

D. Integrally Fused Circuit Breaker:

1. NEMA AB1, molded-case, quick-make/quick-break, mechanically trip-free switching mechanism.
2. Thermal trip for inverse time-delay overload and magnetic trip for instantaneous short-circuit protection. Shunt-trip device for tripping by ground- fault relay as shown. Frame size 400 amperes and above equipped with interchangeable thermal and adjustable magnetic trips.
3. Individually removable current limiter, internally mounted on load side of circuit breaker, with rating and time current limiting characteristics that coordinate with time current-tripping characteristics of circuit breakers to provide the following:
    a. Interruption of circuit breaker under fault-current level up to interrupting capacity of circuit breaker.
    b. Interruption by current limiter in conjunction with circuit breaker under fault-current level above interrupting capacity of circuit breaker.
    c. Where necessary to protect downstream panelboard, limit fault current at branch circuit breakers below their interrupting capacity.
    d. Where necessary to protect associated feeder/branch circuits, limit fault current below short-circuit current withstand capability of cable.
4. Removable cover provided over current-limiter section of circuit breaker with interlock for tripping of breaker upon removal of cover and to prevent turning circuit breaker to ON position with cover removed.
5. Equipped with common trip mechanism for tripping all breaker poles simultaneously on blowing of current limiter to prevent single phasing.
6. Capable of interrupting minimum fault current of 100,000-rms symmetrical amperes at 480 volts ac.
7. Circuit breaker rating:
    a. Number of poles: As shown.
    b. Frame size: As shown.

c. Voltage rating: 480 volts.

d. Interrupting capacity: As necessary to coordinate with current limiter.

e. Trip setting: As shown.

E. Enclosed Circuit Breaker (with thermal magnetic overload):

1. NEMA AB1.

2. Circuit breaker: As shown and as specified. Overcurrent trip device coordinated to provide selective tripping under overload conditions.

3. Enclosure:

a. Galvanized steel, surface-mounted, unless otherwise shown.

b. Type:

1) Above-ground indoor locations and electrical rooms: NEMA 250, Type 1.

2) Outdoor locations: NEMA 250, Type 3R.

F. Enclosed Circuit Breaker (with magnetic trip for motor protection only):

1. NEMA AB1.

2. Circuit breaker: As shown and as specified. Overcurrent trip device coordinated to provide selective tripping under overload conditions.

3. Enclosure:

a. Stainless steel, surface-mounted, unless otherwise shown.

b. Type:

1) Above-ground indoor locations and electrical rooms:

4. NEMA 4X. Outdoor locations: NEMA 250, Type 3R.

G. Panelboard:

1. Enclosure:

a. Surface-mounted unless otherwise shown.

b. NEMA 250 Enclosure Type:

1) Conditioned space above grade: Type 1.

2) Open shop areas: Type 12

3) Exterior, exposed: Type 4X

4) Outside non-conditioned electrical rooms: Type 4X.

c. Gutter size:

Main Bus Rating Amperes	Minimum Top and Bottom Gutter Size in Inches	Minimum Side Gutter Size in Inches
100 and below	4	4
225	6	4
400 and over	8	4

d. Interior components mounted on backplate of reinforced steel for rigid support and accurate alignment.

e. Provide latch and handle in accordance with UL 50; screw fastenings will not be accepted in lieu of latch.

f. Provision for enclosure grounding.

2. Busbars:

a. ASTM B187/B187M-06.

b. 98-percent-conductivity copper.

c. Contact surface silver-plated or tin-plated.

d. Rating of neutral and ground bus: Equal to that of phase bus.

e. Neutral bus mounted on insulating block.

f. Neutral and ground busbars equipped with integral mechanical connectors.

3. AC panelboards:

a. Conform to NEMA PB 1.

b. Type of service: Three-phase, four-wire, 277/480 volt or 120/208 volt or as shown.

c. Type of main: Main lugs or circuit breakers as shown, conforming to requirements specified, located at top or bottom as necessary

d. Branch circuit: Circuit breakers as shown, conforming to requirements specified, number of circuits as shown.

e. Circuit breaker: Trip device coordinated with that of upstream circuit breakers to provide selective tripping.

f. Suitable for service entrance where necessary.

4. DC Panelboard:

a. Type of service: 125-volt dc, two-wire.

b. Type of main: Two-pole circuit breaker, 100-ampere frame, 100-ampere trip and 10,000-ampere interrupting capacity, unless otherwise shown.

c. Branch circuit: Two-pole circuit breakers, 100-ampere frame and 10,000-ampere interrupting capacity, in accordance with specified requirements, quantities as follows unless otherwise shown:

1) With 20-ampere trip: Two minimum.

2) With 30-ampere trip: Two minimum.

3) With 50-ampere trip: Two minimum.

d. Enclosure finish: As specified under General Requirements for this section, except color to be OSHA red as specified in Section 09 91 99.

5. Main Emergency-power panelboard in A.C. Switchboard Room:

a. NEMA PB1, UL 67, circuit breaker type, unless shown otherwise.

b. Enclosure:

1) Galvanized steel, surface-mounted unless otherwise shown.

2) Type:

a) Above-ground indoor locations and electrical rooms: NEMA 250, Type 1.

b)

3) Minimum of four inches side gutter and six inches top and bottom gutter.

4) Mounting channel drilled and tapped to accommodate any combination of fused switch.

c. Busbar:

1) ASTM B187/B187M-06.

1) 98-percent-conductivity copper.

2) Contact surface silver-plated or tin-plated.

3) Rating of neutral and ground bus: Equal to that of phase bus.

4) Neutral bus mounted on insulating block.

5) Drilled and tapped to accommodate any combination of fused switch unit.

6) Neutral and ground bus equipped with integral mechanical connectors.

d. Type of service: As shown.

e. Type of mains: Main lugs or main circuit breaker as shown, located at top or bottom as necessary.

f. Branch circuit: Equipped with circuit breakers, number of circuits as shown.

H. Nameplates:

1. Three-ply, laminated phenolic plates engraved through black face to white core and attached by stainless-steel rivets or screws.

2. Lettering: Vertical gothic using round or square cutter. V-shape groove is prohibited.

3. Each panelboard labeled with nameplate one-inch high bearing ½ inch high inscriptions as appropriate.

4. Nameplate for emergency-power panelboard to bear inscription EMERGENCY POWER.

I. Load Centers:

1. Enclosure:

a. UL 891, stainless steel, ASTM A276-06, Type 304, or approved equal.

b. Type:

1) Above-ground indoor locations and electrical rooms: Non-ventilated indoor.

2) Underground locations, except electrical rooms and tunnel areas: Non-ventilated outdoor.

3) Outdoor locations and tunnel areas: Non-ventilated outdoor.

2. Transformer:

a. NEMA ST20, dry, self-cooled, epoxy-encapsulated, double-wound with insulated copper conductor with 185ºC- insulation system capable of withstanding full-wave impulse voltage of 10KV.

b. Five kVA load center: Single-phase, 60 Hertz, 480 volts primary to 120/240 volts secondary.

c. Nine kVA load center: Three-phase, 60 Hertz, 480 volts primary to 120/208Y volts secondary.

d. Fifteen kVA load center: Three-phase, 60 Hertz, 480 volts primary to 120/208Y volts secondary.

e. Maximum allowable temperature rise under continuous full load above ambient temperature of 30 degrees Celsius and 40 degrees Celsius maximum:

1) By winding resistance: 115 degrees Celsius.

2) By hottest spot in winding: 145 degrees Celsius.

3. Circuit breaker:

a. Bolt-on or plug-in, as specified.

b. Primary circuit breaker: 480 volts, bolt-on, 14,000-rms symmetrical amperes interrupting capacity, 100-ampere frame, with the following

additional requirements:

1) For five kVA load center: Two-pole breaker with 20 ampere trip setting.

2) For nine kVA load center: Three-pole breaker with 25 ampere trip setting.

3) For 15 kVA load center: Three-pole breaker with 40 ampere trip setting.

c. Secondary main circuit breaker:

1) Bolt-on, two or three poles as shown, 240 volts, 10,000 rms symmetrical amperes interrupting capacity with trip setting as follows:

a) For five kVA load center: 25 amperes.

b) For nine kVA load center: 30 amperes.

c) For 15 kVA load center: 50 amperes.

d. Branch circuit breaker:

1) Single-pole, plug-in, 120 volts, 10,000-rms symmetrical amperes interrupting capacity.

a) For five kVA load center: Four breakers, each with 20-ampere trip setting.

b) For nine kVA load center: Six breakers, each with 20-ampere trip setting.

c) For 15 kVA load center: Twelve breakers, each with 20-ampere trip setting.

e. Nameplate: Laminated plastic, one-inch high, attached by Means of stainless-steel rivets or screws, showing load-center number in 1/2-inch high white characters engraved on black background.

4. Neutral and ground bus bar equipped with mechanical connectors.

J. Current-Limiting Circuit Breaker:

1. NEMA AB1, UL 489, molded-case, quick-make/quick-break, mechanically trip-free switching mechanism.

2. Thermal trip for inverse time-delay overcurrent protection and magnetic trip for instantaneous short-circuit protection. Shunt trip device for tripping by ground-fault relay as shown.

3. Limit the fault current, without the use of fusible element, to provide the following:

a. Protect associated cable by limiting the fault let-through energy to a value below the short-circuit withstand capability of the cable.

b. Protect downstream panelboard by limiting fault current at branch circuit breakers within their interrupting capabilities.

4. Circuit-breaker rating:

   a. Number of poles: As shown.

   b. Frame size: As shown.

   c. Voltage rating: 480 volts.

   d. Interrupting capacity: Minimum 100,000-symmetrical RMS amperes.

   e. Trip setting: As shown.

   f.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install panelboards at locations shown, with bottom not less than 12 inches above floor. Use multiple-section panelboards to meet such spacing's if necessary.

B. Mount panelboards and load centers with front straight and plumb.

C. When feeder serves more than one panelboard or panelboard section, install separate junction box or provide adequate gutter area for termination of feeders and bus taps.

D. Install single and/or multiple-conductor cable in accordance with Section 16120. Connect branch circuit wires as shown. Connect neutral wire of branch circuit to neutral bar in panelboard.

E. Install load centers where shown.

F. Make conduit connections in accordance with Section 16130.

G. Make power cable connections to circuit breakers, integrally fused circuit breakers, fused switch units, neutral and ground bus bars in panelboard and load centers and enclosed circuit breakers by means of integral mechanical connectors. If such items are not furnished with integral mechanical connectors, make connections using compression connectors in accordance with Section 16125.

H. Ground panelboards, load centers and enclosed circuit-breaker enclosures in accordance with Section 16060 and the NEC.

I. Apply matching touch-up paint where necessary.

J.

3.2 DIRECTORY OF CIRCUITS

A. Furnish each panelboard and load center with legibly printed circuit directory located on inside of enclosure.

3.3 FIELD QUALITY CONTROL

A. Engage a qualified testing and inspection agency to ensure that the work is in conformance with applicable specifications and perform tests required by this specification.

B. Submit test procedures in accordance with the Contract documents for approval and

perform approved tests. Do not perform tests without approved test procedure. Furnish the equipment, personnel to perform the following tests:

1. Molded-case circuit breakers: Perform pole-to-pole and pole-to- ground insulation resistance tests with 1,000V dc megger. Insulation resistance to be 50 megohms minimum.
2. Panel boards and load centers: Perform insulation-resistance tests of each bus section phase-to-phase and phase-to-ground for one minute using 1,000V megger. Insulation resistance to be not less than manufacturer's recommended minimum or two megohms minimum.
3. Test circuit connections in accordance with wiring diagram.
4. Test panelboard and load-center enclosures for continuity to grounding system.
5. Check cable connections to circuit breakers and fused switch unit for tightness.
6. Check setting of adjustable magnetic trips for compliance with approved coordination study.

C. Submit certified test reports.

D. Submit Operation and Maintenance Manual.

END OF SECTION

WASHINGTON AREA METROPOLITAN TRANSIT AUTHORITY

TUNNEL FAN CONTROL SYSTEM

COVER SHEET

JANUARY 15, 2016

DEPARTMENT OF TRANSIT INFRASTRUCTURE AND ENGINEERING SERVICES

CENI - POWER SYSTEMS ENGINEERING

100% DESIGN

APPROVED

DATE

R. LOUIS VINER JR.
CHIEF ENGINEER - INFRASTRUCTURE

INDEX OF DRAWINGS:

"PROFESSIONAL CERTIFICATION: I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND."

LICENSE No. _____.

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DESIGNED	C. Lesefske	9-4-2015 DATE
DRAWN	Y. Liu	9-16-2015 DATE
CHECKED	P. Petersen	9-24-2015 DATE

REFERENCE DRAWINGS

NUMBER	TITLE

REVISIONS

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WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DEPARTMENT OF TRANSIT INFRASTRUCTURE AND ENGINEERING SERVICES
CENI - POWER SYSTEMS ENGINEERING

DATE

APPROVED
ASHTON ROBINSON
DEPUTY CHIEF ENGINEER
DATE

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	1 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\MECH\PLC PANEL LAYOUT\CAD\ST-ME-FAN-100 INDEX OF DRAWINGS.DWG
Plotted by: E011967 Date: Thu, 24 Mar 2016 Time: 04:11:35 pm
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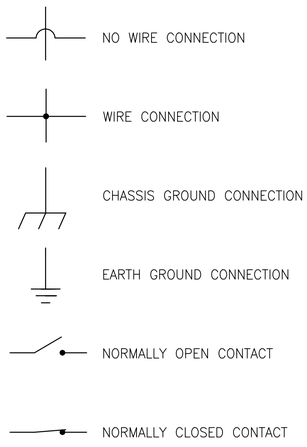
Images: ; DC_Architect.jpg ; DC_Engineer.jpg ; MARYLAND_ARCHITECT.jpg ; MARYLAND_ENGINEER.jpg ; Virginia_Architect.jpg ; Virginia_Engineer.jpg ; N:\ROBINSON-ELECT-MECH\MECH\CAD Standard\DWG BLOCKS\Bor

SYMBOLS:



WIRE COLOR CODES:			
COLOR(S)	FUNCTION	SIZE	TYPE
GREEN	ISOLATED GROUND	18 AWG	STRANDED MTW OR THHN
GREEN W/YELLOW STRIPE	CHASSIS / FRAME GROUND	18 AWG	STRANDED MTW OR THHN
BLACK	UNFILTERED 120VAC POWER	18 AWG	STRANDED MTW OR THHN
WHITE	NEUTRAL FOR 120VAC	18 AWG	STRANDED MTW OR THHN
BLUE	(+)24VDC POWER	18 AWG	STRANDED MTW OR THHN
WHITE W/BLUE STRIPE	NEGATIVE 24VDC	18 AWG	STRANDED MTW OR THHN
RED	FILTERED 120VAC POWER	18 AWG	STRANDED MTW OR THHN
BROWN	MISC CIRCUITS	18 AWG	STRANDED MTW OR THHN
YELLOW	MISC CIRCUITS	18 AWG	STRANDED MTW OR THHN
ORANGE	120VAC POWER FROM EXTERNAL EQUIPMENT	18 AWG	STRANDED MTW OR THHN
PURPLE	ANALOG CIRCUITS	18 AWG	STRANDED MTW OR THHN

TERMINAL BLOCK COLOR CODES:	
COLOR(S)	FUNCTION
GREEN	ISOLATED GROUND
GREEN W/YELLOW STRIPE	CHASSIS / FRAME GROUND
BLACK	UNFILTERED 120VAC POWER
RED	FILTERED 120VAC POWER
GRAY	120VAC NEUTRAL AND 24VDC NEGATIVE
BLUE	(+) 24VDC POWER
BROWN	MISC CIRCUITS
YELLOW	MISC CIRCUITS
ORANGE	120VAC POWER FROM EXTERNAL EQUIPMENT

ABBREVIATIONS:

AHU	AIR HANDLING UNIT
AMP	AMPERE
AWG	AMERICAN WIRE GAUGE
BL	BLUE
BLK	BLACK
CB	CIRCUIT BREAKER
C	COMMON
COMM	COMMUNICATION
CPU	CENTRAL PROCESSING UNIT
DDC	DIRECT DIGITAL CONTROL
DIN	DEUTSCH INSTITUT FUR NORMUNG
DP	DIFFERENTIAL PRESSURE
DPDT	DOUBLE POLE DOUBLE THROW
DTS	DATA TRANSFER SYSTEM
EA	EACH
EF	EXHAUST FAN
GND	GROUND
GRN	GREEN
GRY	GRAY
HMI	HUMAN MACHINE INTERFACE
HOA	HAND-OFF-AUTO
LS	LIMIT SWITCH
mA	MILLIAMPS
MAX	MAXIMUM
MFR	MANUFACTURER
MIN	MINIMUM
MOV	METAL OXIDE VARISTOR
MS	MOTOR STARTER
MTW	MACHINE TOOL WIRE
NC	NORMALLY CLOSED
NEMA	NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
NIC	NOT IN CONTRACT
NO	NORMALLY OPEN
NTS	NOT TO SCALE
OD	OUTSIDE DIAMETER
ORG	ORANGE
PLC	PROGRAMMABLE LOGIC CONTROLLER
POE	POWER OVER ETHERNET
PTT	PUSH TO TEST
R	RELAY
RH	RELATIVE HUMIDITY
RTD	RESISTANCE TEMPERATURE DETECTOR
SP	SUMP PUMP
SPDT	SINGLE POLE DOUBLE THROW
SPST	SINGLE POLE SINGLE THROW
SS	STAINLESS STEEL
SWGR	SWITCHGEAR
T	TERMINAL
TB	TERMINAL BLOCK
TCP	TRANSMISSION CONTROL PROTOCOL
THHN	THERMOPLASTIC HIGH HEAT RESISTANT NYLON
TPSS	TRACTION POWER SUBSTATION
TYP	TYPICAL
UH	UNIT HEATER
V	VOLT
VAC	VOLTS ALTERNATING CURRENT
VDC	VOLTS DIRECT CURRENT
VU	VENTILATOR UNIT
W/	WITH
WMATA	WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
WHT	WHITE
YEL	YELLOW
#	NUMBER

GENERAL NOTES:

1. ALL PENETRATIONS INTO NEMA RATED ENCLOSURE SHALL BE MADE IN A MANNER TO MAINTAIN THEIR RESPECTIVE NEMA RATING(S).
2. PENETRATIONS INTO THE TOP OR BACK SIDES OF CONTROL PANEL ENCLOSURE SHALL BE AVOIDED IF POSSIBLE.
3. DOUBLE LEVEL TERMINAL BLOCK NUMBERING SHALL BE REPRESENTATIVE OF THE LOWER LEVEL CONSISTING OF EVEN NUMBERING WHILE THE UPPER LEVEL IS ODD NUMBERING.
4. TERMINAL NUMBERING SHALL BE FROM THE LEFT TO RIGHT DIRECTION ON HORIZONTAL TERMINAL SEGMENTS. NUMBERING SHALL BE FROM TOP TO BOTTOM ON VERTICAL TERMINAL SEGMENTS.
5. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.
6. TERMINAL BLOCK END COVERS SHALL BE INSTALLED AS TO COVER THE INTERNAL EXPOSED METAL CONDUCTORS IN END TERMINAL BLOCKS.
7. INTERNAL ENCLOSURE DEVICES AND TERMINAL BLOCKS SHALL BE IDENTIFIED BY MACHINE PRINTED LABELS OF HEIGHT 1/2 INCH. THIS LABEL SHALL BE INSTALLED 1/4 INCH ABOVE EACH DEVICE AND TERMINAL BLOCK ON THE BACK PLATE. THE LABEL SHALL BE WHITE IN COLOR WITH BLACK TEXT.
8. THE SHIELDING AND TWISTED CONDUCTOR ARRANGEMENT IN COMMUNICATIONS AND ANALOG CABLES SHALL BE LEFT INTACT AS CLOSE AS POSSIBLE TO THEIR TERMINATION POINT TO MINIMIZE ELECTRICAL NOISE.
9. THE SHIELDING/DRAIN WIRES IN COMMUNICATION AND ANALOG CABLES SHALL BE GROUNDED AT ONE END ONLY. THIS SHIELDING MAY BE CONSOLIDATED AND GROUNDED AT ONE POINT ONLY. THE OPPOSITE CABLE ENDS SHALL HAVE THEIR SHIELDING AND DRAIN WIRES CUT BACK TO WHERE THE CABLE JACKETING ENDS AND BE TAPED OVER.
10. THE ROUTING OF COMMUNICATIONS AND ANALOG CABLING SHALL BE DISTANCED AS FAR AS PRACTICAL FROM 120VAC OR 24VDC POWER CIRCUITS.
11. WIRES OF SIZE AWG 16 AND SMALLER SHALL HAVE INSTALLED SLEEVED FERRULES AT EACH TERMINATION POINT. IT IS PERMISSIBLE TO USE TWO WIRES INSIDE ONE FERRULE IF ITS DESIGNED FOR IT
12. ALL WIRING EXTERNAL OF CONTROL PANEL SHALL BE IN CONDUIT. CONDUIT SHALL BE OF RIGID STEEL TYPE OF 3/4 INCH OR GREATER AS INDICATED OR AS REQUIRED BY THE NEC.
13. USE MAXIMUM 6 FOOT LENGTHS OF FLEXIBLE CONDUIT FOR FINAL CONNECTIONS TO EQUIPMENT SUBJECT TO VIBRATION, NOISE TRANSMISSION, AND ALL MOTORS. INSTALL GROUND CONDUCTORS ACROSS ALL FLEXIBLE CONNECTIONS. IT IS PREFERRED TO HAVE FLEXIBLE CONDUIT TERMINATE IN STRAIGHT CONNECTORS AS OPPOSED TO ELBOWS.
14. CONDUCTORS SHALL BE INSTALLED CONTINUOUS BETWEEN DEVICES AND CONTROL PANELS. SPLICES OR CONNECTIONS SHALL BE MADE ONLY IN JUNCTION BOXES. AT MINIMUM 8 INCH LOOPS SHALL REMAIN WHERE CONNECTIONS ARE MADE.
15. ALL COMMUNICATIONS AND ANALOG CABLING RUNS SHALL BE CONTINUOUS WITH NO SPLICES.
16. ALL PENETRATIONS OF FLOORS AND WALLS SHALL BE FIRE STOPPED IN ACCORDANCE WITH NEC, AND NFPA.
17. HARD AND ELECTRONIC COPIES OF ALL AS BUILT FIELD CONTROL WIRING SHALL BE PROVIDED TO THE OWNER AT THE PROJECT END.
18. CONCRETE ANCHORS AND FASTENERS SHALL BE OF 316 STAINLESS STEEL IN TYPE.
19. THE PLC BASED TUNNEL VENTILATION CONTROL PANEL SHALL CARRY THE UL 508A LISTING MARK.

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WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

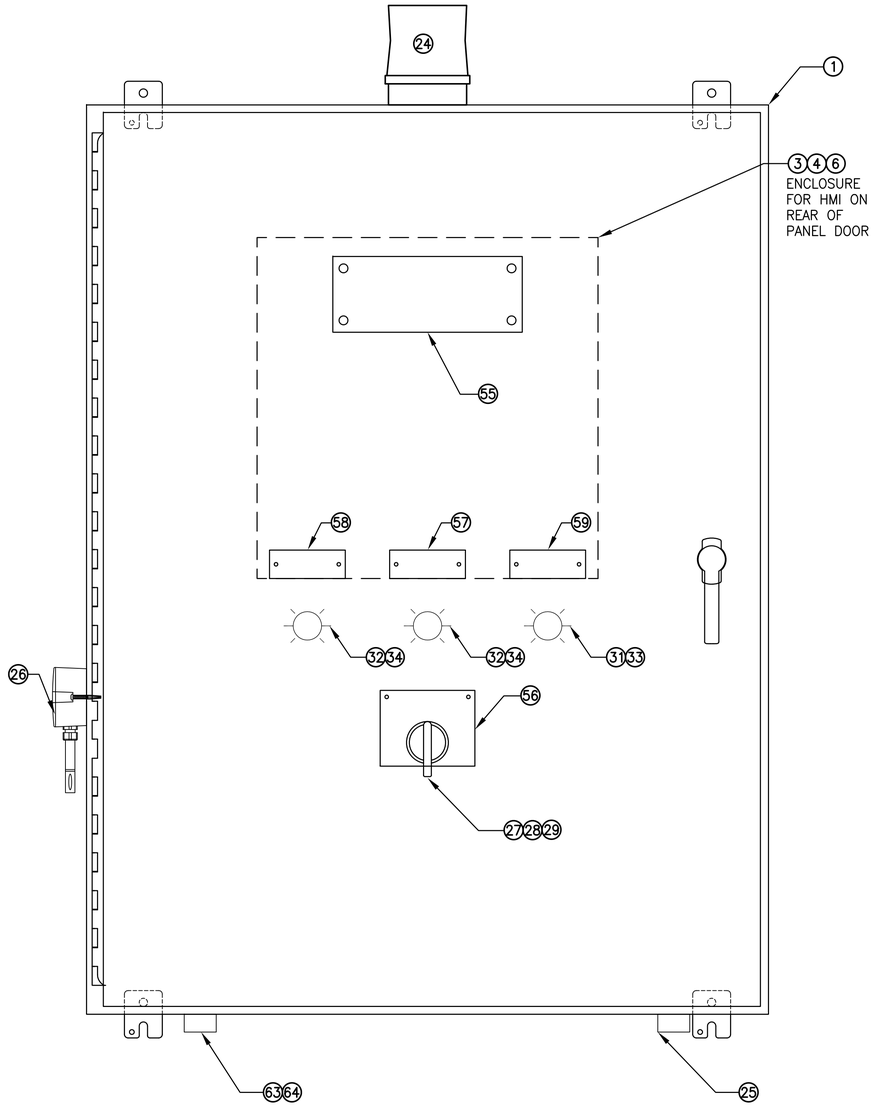
DEPARTMENT OF TRANSIT INFRASTRUCTURE AND ENGINEERING SERVICES
CENI - POWER SYSTEMS ENGINEERING

DATE

APPROVED
ASHTON ROBINSON
DEPUTY CHIEF ENGINEER
DATE

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	2 of 42



1/100 EXTERIOR VIEW OF CONTROL PANEL

SCALE: 3" = 1'-0"

CONTROL PANEL EQUIPMENT SCHEDULE

#	DESCRIPTION	QTY.	PART NO.	MANUFACTURER
1	ENCLOSURE, 48"H X 36"W X 12"DEEP, NEMA 4X 316 SS, QUARTER TURN HANDLE	1	A48H3612SS6LP3PT	HOFFMAN
2	ENCLOSURE INTERNAL SUB PANEL, STEEL– PAINTED WHITE	1	A48P36	HOFFMAN
3	ENCLOSURE, 18"H X 18"W X 4"DEEP, NEMA 1, GRAY PAINTED STEEL	1	1ZHN1	WIEGMANN
4	HUMAN MACHINE INTERFACE (HMI) TOUCH SCREEN, 12" SCREEN	1	EA9–T12C	C–MORE
5	POWER FILTER, TRANSIENT RING WAVE AND SURGE ARRESTOR, 30AMP, 120VAC, W/ 4 FEET LEADS ON MONITORING CIRUIT	1	S–SP120–PC3–4FTDIN–70	SURGE SUPRESS INC
6	COMMUNICATIONS CABLE, 15 PIN TO RJ–12, PLC TO HMI COMMUNICATION	1	EA–2CBL	AUTOMATION DIRECT
7	PLC BASE, 8 SLOT, DIN RAIL MOUNTED, 140 DEGREES F MAX OPERATING TEMP	2	P3–08B	AUTOMATION DIRECT
8	PLC POWER SUPPLY, 120VAC INPUT POWER, 57 MAX WATTAGE OUTPUT	2	P3–01AC	AUTOMATION DIRECT
9	CPU FOR P3000, 50MB LCD, (2) RJ45 ETHERNET, (1) RS485, (2) USB	1	P3–550	AUTOMATION DIRECT
10	PLC INPUT MODULE, 120VAC DIGITAL, 16 POINT	5	P3–16NA	AUTOMATION DIRECT
11	PLC INPUT MODULE, 24VDC DIGITAL, 16 POINT	1	P3–16ND3	AUTOMATION DIRECT
12	PLC INPUT MODULE, ANALOG, 0–20MA, 16 POINT, 16 BIT RES	2	P3–16AD–1	AUTOMATION DIRECT
13	PLC OUTPUT MODULE, RELAY, 16 POINT, FORM "A", 1.25 AMPS PER POINT	1	P3–16TR	AUTOMATION DIRECT
14	PLC OUTPUT MODULE, RELAY, 8 POINT, 6.3 AMPS PER POINT, 8 COMMONS	7	P3–08TRS–1	AUTOMATION DIRECT
15	PLC MODULE WIRE TERMINATION BLOCK, SCREW TERMINALS	16	P3–RTB	AUTOMATION DIRECT
16	PLC OUTPUT MODULE SPARE FUSES, PER 5 PACK	2	P3–FUSE–2	AUTOMATION DIRECT
17	PLC EXPANSION MODULE W/ REQUIRED USB COMM CABLE FOR PLC #2	1	P3–EX	AUTOMATION DIRECT
18	RELAY SOCKET, DIN RAIL MOUNTABLE, FOR DPDT ICE CUBE RELAY	9	782–2C–SKT	AUTOMATION DIRECT
19	RELAY, ICE CUBE, DPDT, 120VAC COIL, 15 AMP @120VAC RATED, LED TYPE	9	782–2C–120A	AUTOMATION DIRECT
20	MOV MODULE, PLUG IN, FOR RELAY CIRCUITRY TRANSIENT PROTECTION	14	AD–BSMM–120	AUTOMATION DIRECT
21	POWER SUPPLY, 24VDC @ 2.5 AMPS OUTPUT, METAL, DIN RAIL MOUNTED	1	PSB24–060S–P	AUTOMATION DIRECT
22	PRESSURE TRANSDUCER, 4–20MA OUTPUT, 24VDC POWERED, 0–100PSI	2	PTD25–20–0100H	AUTOMATION DIRECT
23	PRESSURE TRANSDUCER, CABLE	2	CD12L–0B–020–A0	AUTOMATION DIRECT
24	STROBE LIGHT, AMBER, 90 FLASH PER MIN, 120VAC	1	4A964	FEDERAL SIGNAL
25	AUDIBLE WARNING BEEPER, 120VAC, 95DB, MEDIUM PULSE, REMOVABLE CONNECTOR	1	SCE120LA2MP1B	MOLLORY–SONALERT
26	TEMPERATURE AND RH TRANSMITTER, 4–20MA OUTPUT, NEMA 4X RATED	2	EE160–HT6XAPAB–TX004M	E+E ELEKTRONIK
27	SWITCH BODY, 4 POSITION MAINTAINED, DUST AND WATER TIGHT	1	5B483	SCHNEIDER ELECTRIC
28	SWITCH HANDEL, ORANGE, OVERSIZED	1	5B459	SCHNEIDER ELECTRIC
29	CONTACT BLOCK FOR SELECTOR SWITCH, 1 N.O., 1 N.C. PER BLOCK	2	5B537	SCHNEIDER ELECTRIC
30	CONVENIENCE OUTLET, (3) 5–15 RECEPTACLES, 15 AMPS @ 120VAC, DIN MOUNTED	1	FA–REC3	AUTOMATION DIRECT
31	INDICATOR LIGHT, GREEN, 33MM, METAL, PTT, 120VAC, NEMA 4X/12 RATED	1	HT8GVGV7	EATON
32	INDICATOR LIGHT, AMBER, 33MM, METAL, PTT, 120VAC, NEMA 4X/12 RATED	2	HT8GVAV7	EATON
33	LED BULB ELEMENT FOR INDICATOR LIGHTS, 120VAC, GREEN OUTPUT COLOR	1	HT8LEDGF7	EATON

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CENI - POWER SYSTEMS ENGINEERING

REVISION SUBMITTED _____ DATE

APPROVED _____ DATE
ASHTON ROBINSON
DEPUTY CHIEF ENGINEER

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FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

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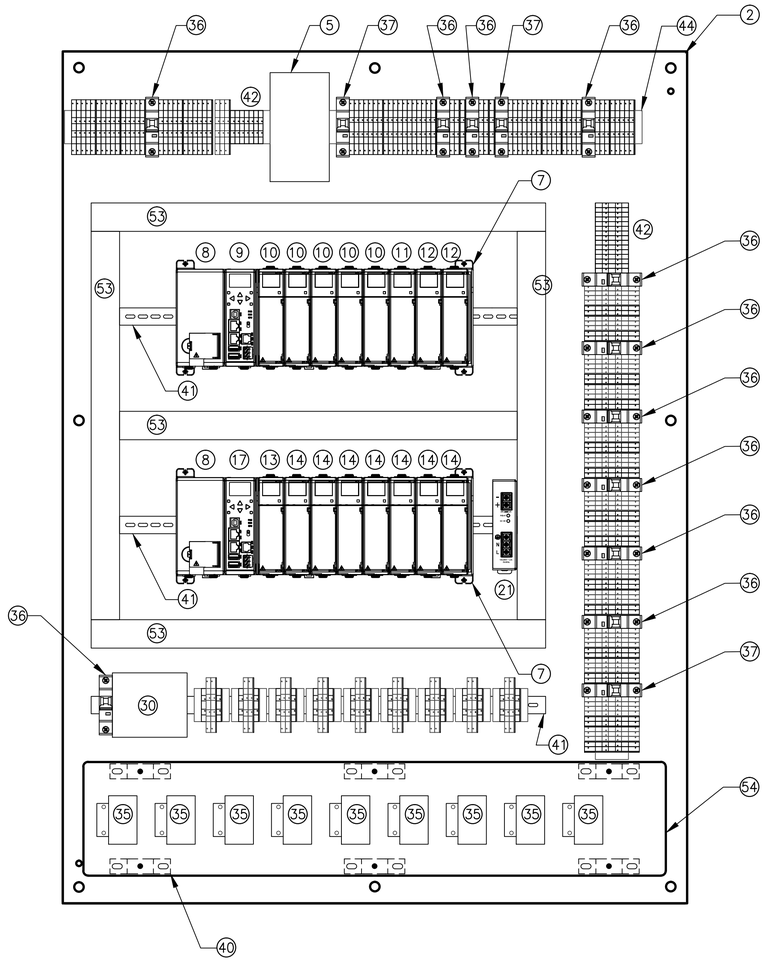

2 / 100 INTERIOR VIEW OF CONTROL PANEL

SCALE: 3" = 1'-0"

CONTROL PANEL EQUIPMENT SCHEDULE (CONT.)

(#)	DESCRIPTION	QTY	PART NO.	MANUFACTURER
34	LED BULB ELEMENT FOR INDICATOR LIGHTS, 120VAC, AMBER OUTPUT COLOR	2	HT8LEDAF7	EATON
35	SOLENOID VALVE, 120VAC COIL, 3 WAY, 1/8" PORT SIZE, W/ BARBS ON PORTS	9	V11HAA-100	JOHNSON CONTROLS
36	CIRCUIT BREAKER, 1 POLE, 2 AMP, "C" TRIP CURVE, UL489 RATED, DIN MOUNTED	12	FAZ-C2-1-NA-SP	EATON
37	CIRCUIT BREAKER, 1 POLE, 5 AMP, "C" TRIP CURVE, UL489 RATED, DIN MOUNTED	2	FAZ-C5-1-NA-SP	EATON
38	CIRCUIT BREAKER, 1 POLE, 15 AMP, "C" TRIP CURVE, UL489 RATED, DIN MOUNTED	0	FAZ-C15-1-NA-SP	EATON
39	CIRCUIT BREAKER, 1 POLE, 25 AMP, "C" TRIP CURVE, UL489 RATED, DIN MOUNTED	0	FAZ-C25-1-NA-SP	EATON
40	DIN RAIL SUPPORT BRACKET STANDOFF, 3.5" STAND OFF, STEEL, 10 PACK	1	DN-SSB90-10	AUTOMATION DIRECT
41	DIN RAIL, 35MM X 7.5MM, 3' EACH, SLOTTED STEEL, 1 BOX HAS 10 PCS	1	DN-R35S1	AUTOMATION DIRECT
42	TERMINAL BLOCK, SINGLE LEVEL, GREEN/YELLOW, #10AWG, 1 BOX OF 50	1	DN-G10	AUTOMATION DIRECT
43	END COVER PLATES FOR SINGLE LEVEL TERMINAL BLOCKS, 1 PACK OF 25.	1	DN-EC1210MN	AUTOMATION DIRECT
44	END BRACKET FOR T10 TERMINALS, 1 PACK OF 50	1	DN-EB35	AUTOMATION DIRECT
45	JUMPER BAR FOR T10 TERMINALS, 25AMP RATED, (5) 24 POLE SEGMENTS -CUT TO LENGTH	1	DN-24J4Y	AUTOMATION DIRECT
46	TERMINAL BLOCK, DOUBLE LEVEL, GRAY, #10AWG, 30AMP @ 600V, 1 BOX OF 50, DIN MOUNT	2	DN-D10-A	AUTOMATION DIRECT
47	TERMINAL BLOCK, DOUBLE LEVEL, BLUE, #10AWG, 30AMP @ 600V, 1 BOX OF 50, DIN MOUNT	2	DN-D10B-A	AUTOMATION DIRECT
48	TERMINAL BLOCK, DOUBLE LEVEL, BLACK, #10AWG, 30AMP @ 600V, 1 BOX OF 50, DIN MOUNT	2	DN-D10BLK-A	AUTOMATION DIRECT
49	TERMINAL BLOCK, DOUBLE LEVEL, ORANGE, #10AWG, 30AMP @ 600V, 1 BOX OF 50, DIN MT.	2	DN-D10ORG-A	AUTOMATION DIRECT
50	TERMINAL BLOCK, DOUBLE LEVEL, RED, #10AWG, 30AMP @ 600V, 1 BOX OF 50, DIN MOUNT	2	DN-D10RED-A	AUTOMATION DIRECT
51	TERMINAL BLOCK, DOUBLE LEVEL, YELLOW, #10AWG, 30AMP @ 600V, 1 BOX OF 50, DIN MT.	2	DN-D10YEL-A	AUTOMATION DIRECT
52	END COVER PLATES FOR DOUBLE LEVEL TERMINAL BLOCKS, 1 PACK OF 50.	1	DN-DEC10	AUTOMATION DIRECT
53	WIRE DUCT W/ COVER, 1.5"W X 4"D X 6'L, WHITE, THIN FINGER, (1) 6 FOOT SEGMENT	4	T1E-1540-1	AUTOMATION DIRECT
54	ALUMINUM PLATE, 30.75" X 6" X 1/8", PLAIN UNFINISHED, 0.25" RADIUS CORNER	1	CUSTOM	CUSTOM
55	PLACARD, ENGRAVED, FAN SHAFT ID	1	CUSTOM	CUSTOM
56	PLACARD, ENGRAVED, FOUR POSITION SELECTOR SWITCH.	1	CUSTOM	CUSTOM
57	PLACARD, ENGRAVED, INDICATOR LIGHT ID PLATE- "LOCAL SUPPLY"	1	CUSTOM	CUSTOM
58	PLACARD, ENGRAVED, INDICATOR LIGHT ID PLATE- "LOCAL EXHAUST"	1	CUSTOM	CUSTOM
59	PLACARD, ENGRAVED, INDICATOR LIGHT ID PLATE- "REMOTE CONTROL"	1	CUSTOM	CUSTOM
60	TERMINAL BLOCK, SINGLE LEVEL, WHITE, #10AWG, 30AMP @ 600V, 1 BOX OF 50, DIN MOUNT	1	DN-T10W-A	AUTOMATION DIRECT
61	TERMINAL BLOCK, SINGLE LEVEL, BLACK, #10AWG, 30AMP @ 600V, 1 BOX OF 50, DIN MOUNT	1	DN-T10BLK-A	AUTOMATION DIRECT
62	TERMINAL BLOCK, DOUBLE LEVEL, GRAY, #10/30 INTERCONNECTED, 1 BOX OF 50, DIN MOUNT	1	DN-D10X-A	AUTOMATION DIRECT
63	RJ-45 PASS-THRU RECEPTABLE, SPRAY PROOF	1	ENSP1F5	WOOHEAD
64	RJ-45 RECEPTACLE CAP WITH LANYARD, SPRAY PROOF	1	67-0300	WOOHEAD
65	USB 2.0 B FEMALE TO B MALE PANEL-MOUNT CABLE (2'-0" BLACK)	1	28073	CABLES TO GO

"PROFESSIONAL CERTIFICATION: I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND."

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- COMAR 09.23.03.10

DESIGNED	C. Lesefske	9-4-2015 DATE
DRAWN	Y. Liu	9-16-2015 DATE
CHECKED	P. Petersen	9-24-2015 DATE

REFERENCE DRAWINGS

NUMBER	TITLE

REVISIONS

DATE	NUM	DESCRIPTION
1/15/2016	1	100% DESIGN

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

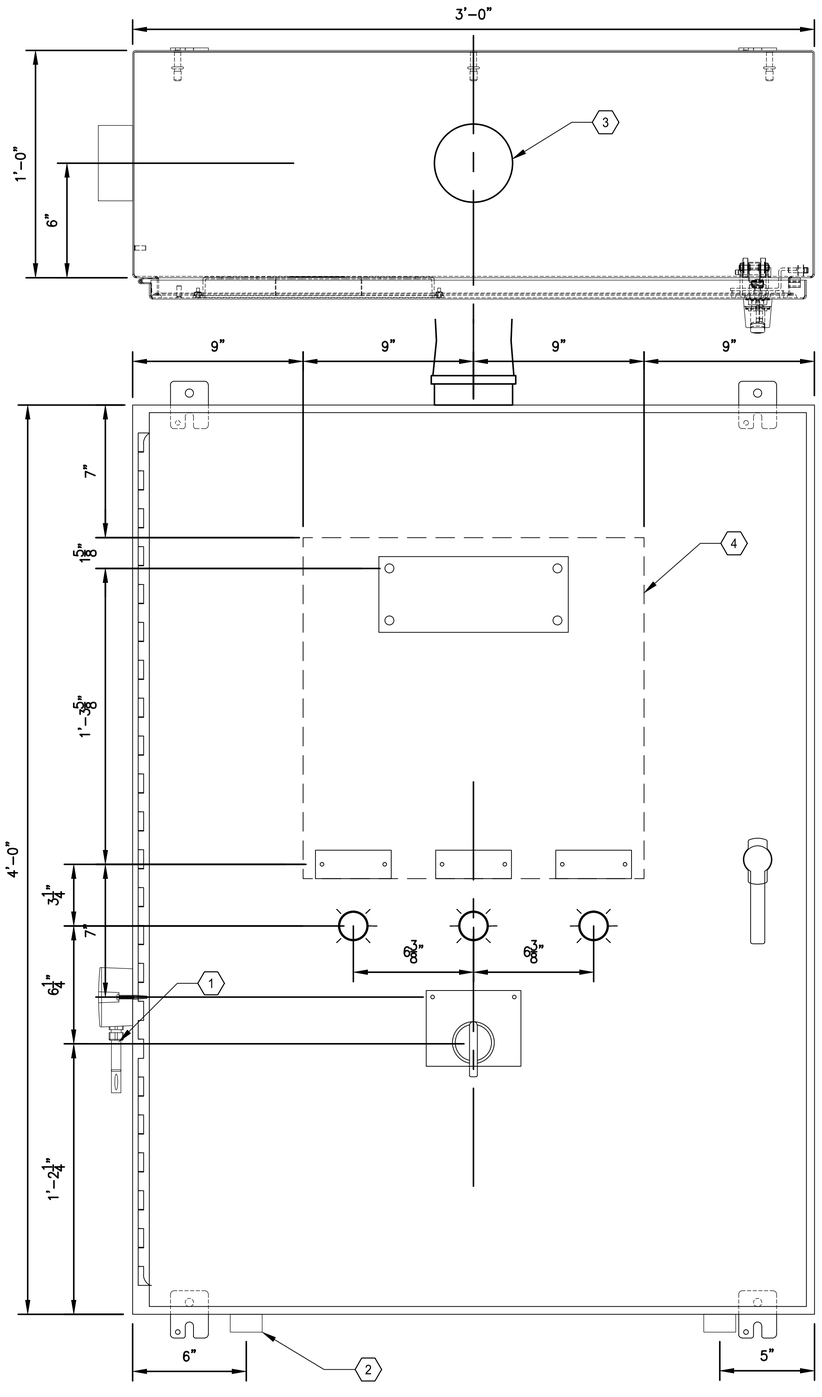
DEPARTMENT OF TRANSIT INFRASTRUCTURE AND ENGINEERING SERVICES
CENI - POWER SYSTEMS ENGINEERING

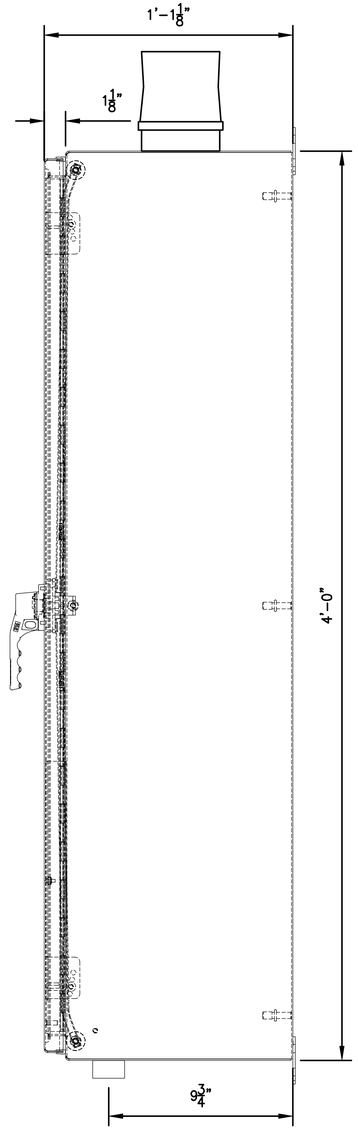
REVISION SUBMITTED _____ DATE

APPROVED _____ DATE
ASHTON ROBINSON
DEPUTY CHIEF ENGINEER

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	4 of 42



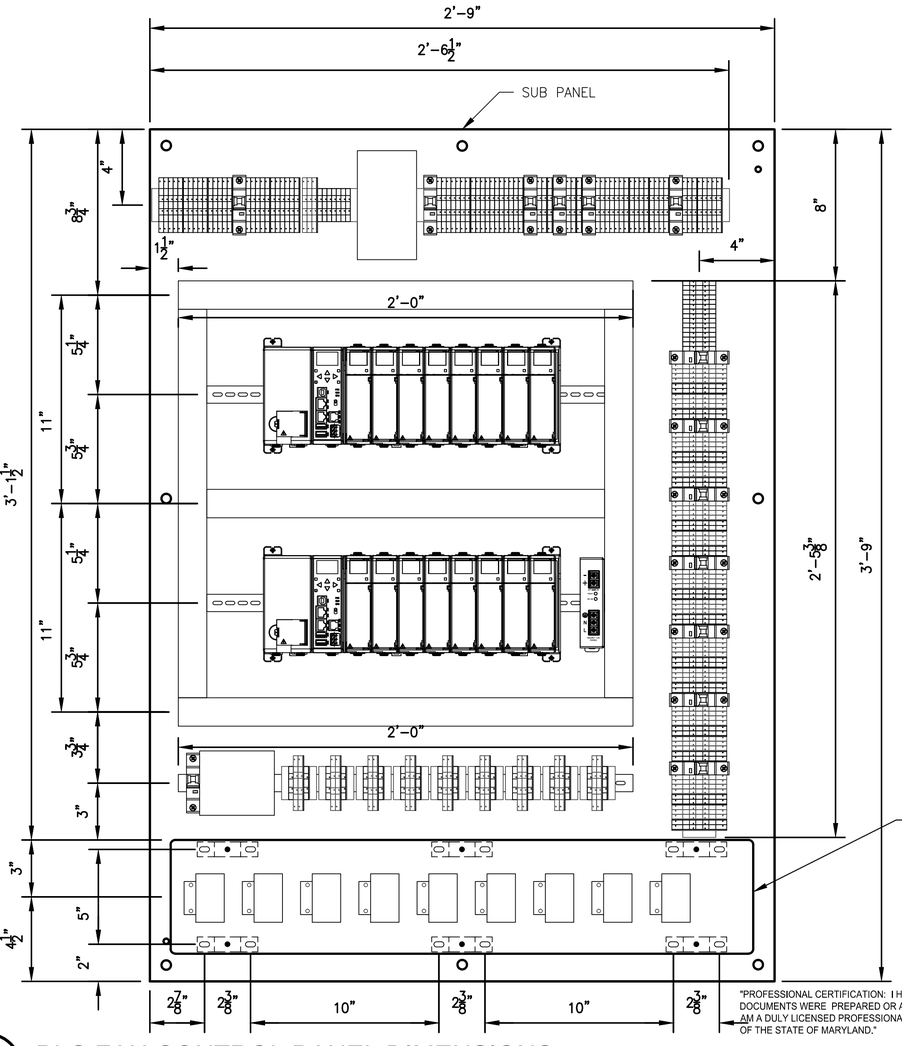


NOTES:

1. TEMP/RH SENSOR SHALL BE ATTACHED TO THE ENCLOSURE BY 316 S.S. MACHINE SCREWS AND VIBRATION PROOF LOCKNUTS. MAKE WATERPROOF BY USE OF RTV SILICON ON THE TOP AND LEFT AND RIGHT SIDES AFTER ATTACHMENT.
2. RJ-45 PORT IS TO BE USED AFTER INSTALL FOR SERVICE TECHNICIAN ACCESS TO WMATA LAN.
3. SEAL STROBE LIGHT BY APPLYING RTV SILICON TO ALL AROUND THE FIXTURE BASE WHERE IT CONTACTS THE ENCLOSURE.
4. THE HMI ENCLOSURE ON THE PANEL DOOR INTERIOR IS FASTENED TO THE PANEL DOOR BY THE EXTERIOR PLACARD FASTENERS.

GENERAL NOTES:

1. EACH DIN RAIL SEGMENT SHALL BE SECURED TO THE INTERNAL SUB PANEL BY #10-32 MACHINE SCREWS IN TAPPED HOLES. EACH SCREW SHALL BE EQUIPPED WITH 0.75" OD FENDER WASHER. NO MOUNTING HARDWARE IS TO BE ON REAR SIDE OF INTERNAL SUB PANEL.
2. WIRE DUCT SEGMENTS SHALL BE FIRST ADHERED TO THE INTERNAL SUB PANEL BY MEANS OF DOUBLE SIDE TAPE. DOUBLE SIDED TAPE SHALL BE ONE INCH WIDE. WIRE DUCT SEGMENTS SHALL THEN RECEIVE #10-32 MACHINE SCREWS IN TAPPED HOLES. EACH SCREW SHALL BE EQUIPPED WITH 0.75" OD FENDER WASHER. NO MOUNTING HARDWARE IS TO BE ON REAR SIDE OF INTERNAL SUB PANEL.
3. THE REQUIREMENT OF HAVING NO MOUNTING HARDWARE ON THE REAR SIDE OF THE INTERNAL SUB PANEL IS TO ALLOW FIELD REMOVAL OF ITEMS WITHOUT THE NEED FOR INTERNAL SUB PANEL REMOVAL TO ACCESS HARDWARE. MACHINE SCREW THREADED PORTIONS ALONE IS PERMITTED TO EXTEND BEYOND THE INTERNAL SUB PANEL.



3
100
PLC FAN CONTROL PANEL DIMENSIONS
SCALE: 3" = 1'-0"

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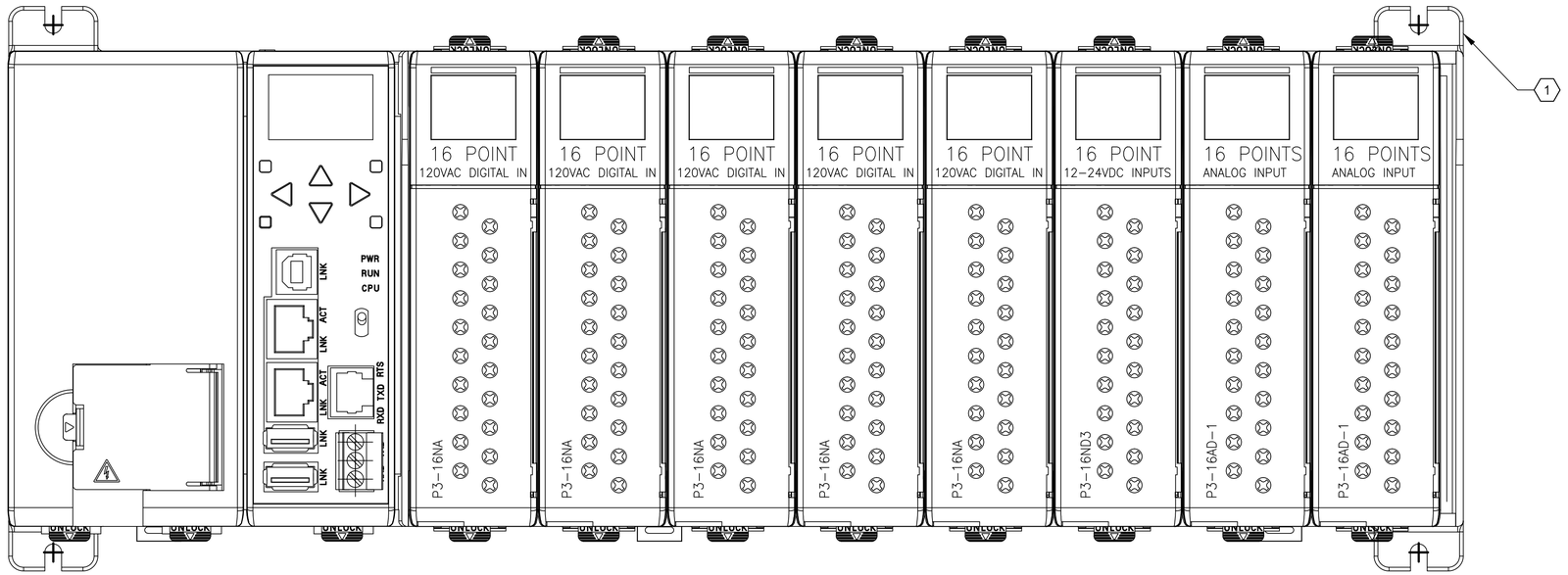
ASHTON ROBINSON DATE
DEPUTY CHIEF ENGINEER

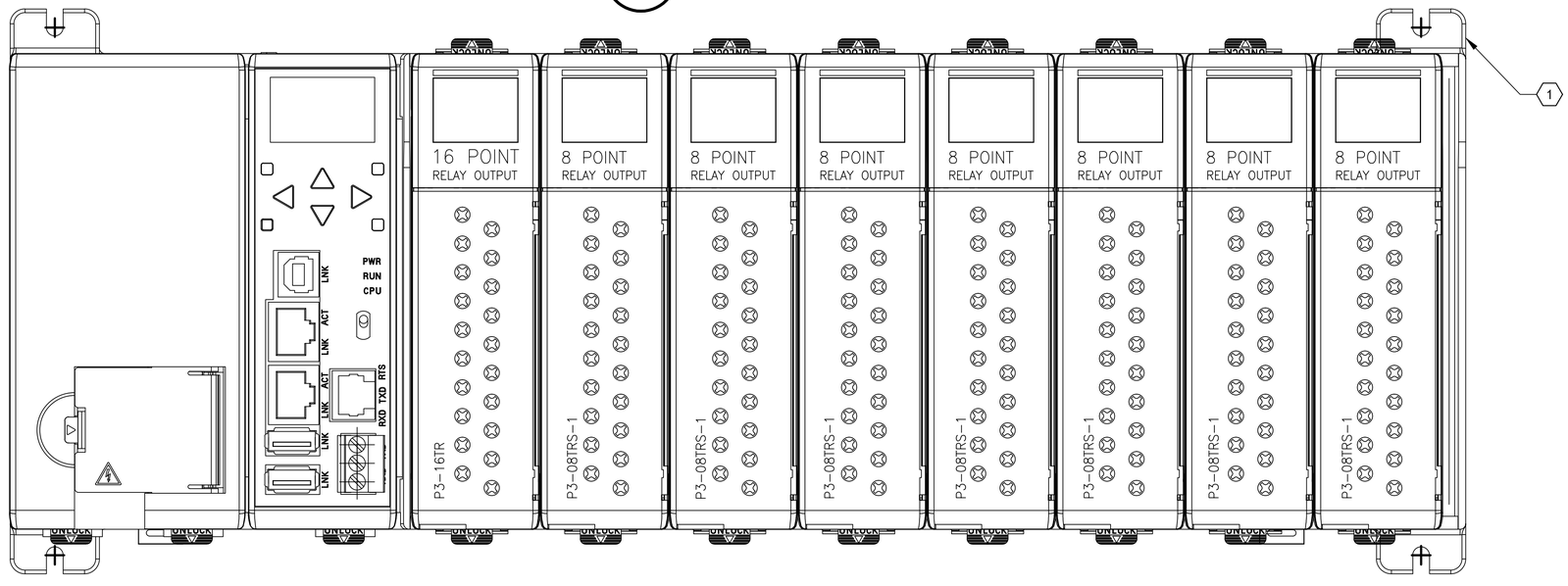
MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	5 of 42



4 / 100 PLC #1 MODULES DETAIL

SCALE: N.T.S.



5 / 100 PLC #2 MODULES DETAIL

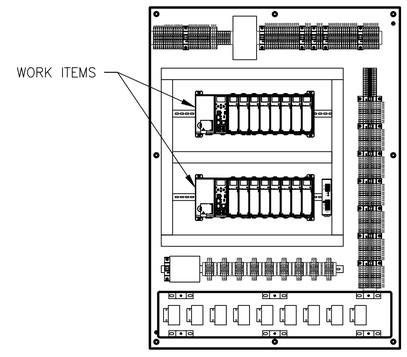
SCALE: N.T.S.

GENERAL NOTES:

1. PLC #1 IS PRELIMINARY INTENDED FOR DTS AND SYSTEM SINKING TYPE INPUTS.
2. PLC #2 IS PRELIMINARY INTENDED FOR RELAY TYPE DRY CONTACT OUTPUTS.

(#) NOTES:

1. PLC BASE SHALL ONLY BE ATTACHED BY DIN RAIL, NO SCREWS IN THE MOUNTING TABS ARE REQUIRED.



KEY PLAN

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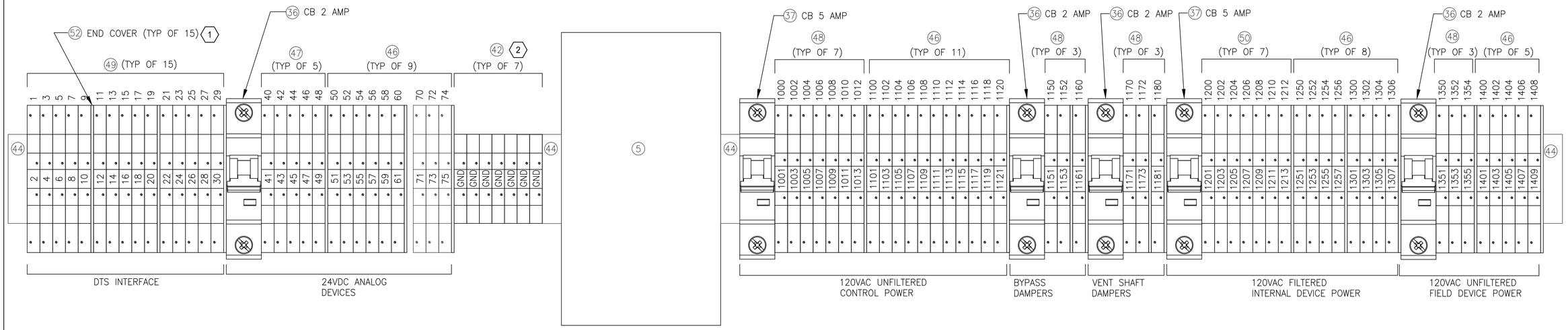
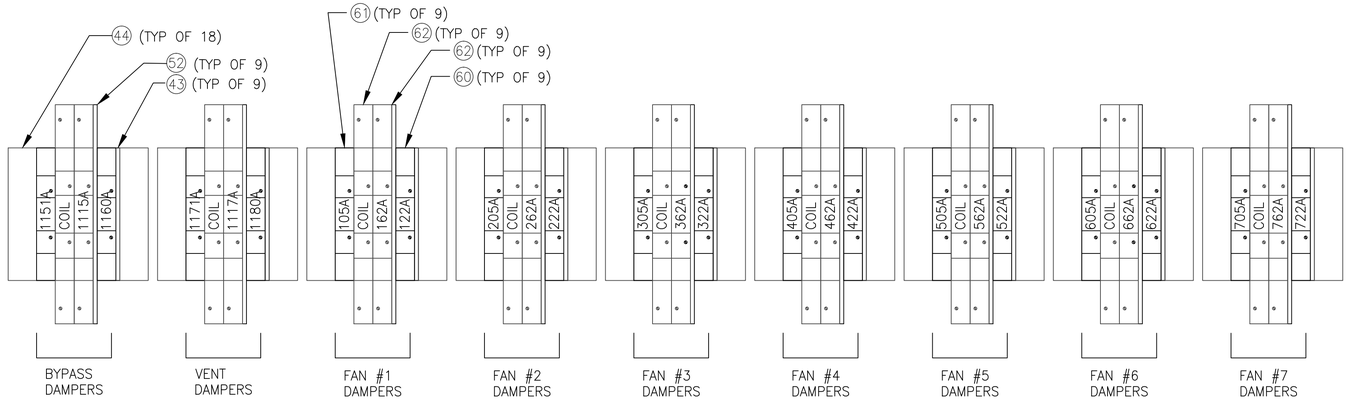
MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	6 of 42



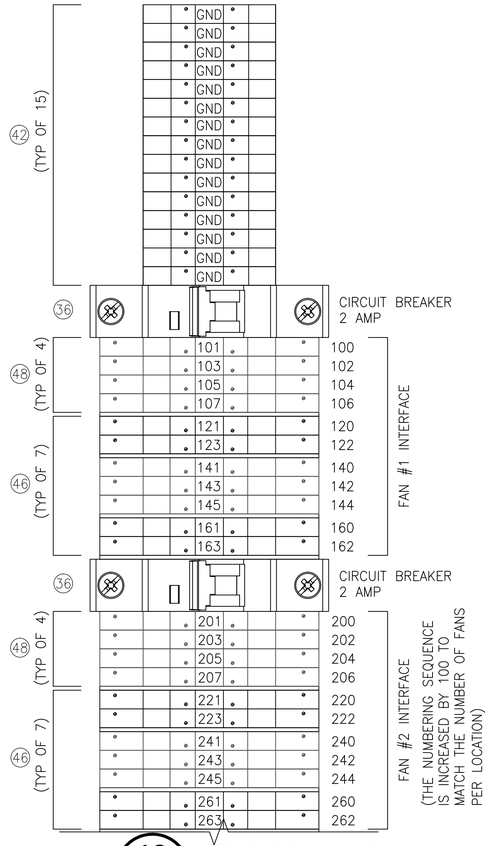
10/100 TB DETAIL-DTS, 24VDC, 120VAC

SCALE: N.T.S.



11/100 TB DETAIL-DAMPERS

SCALE: N.T.S.



12/100 TB DETAIL - FANS

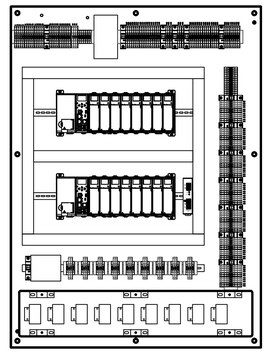
SCALE: N.T.S.

GENERAL NOTES:

1. ALL (#) REFER TO ITEMS IN THE CONTROL PANEL EQUIPMENT SCHEDULE ON DRAWING SHEET 2 OR 3.

⟨#⟩ NOTES:

1. END COVER PLATES SHALL BE COORDINATED WITH THE TERMINAL BLOCKS AS TO COVER THE LAST BLOCKS INTERNAL EXPOSED METAL CONDUCTORS.
2. GROUNDING TERMINAL BLOCKS SHALL BE MECHANICALLY FASTENED TO THE DIN RAIL AS TO MAKE THE TERMINALS ELECTRICALLY CONDUCTIVE WITH ENCLOSURE INTERNAL SUB PANEL.



KEY PLAN

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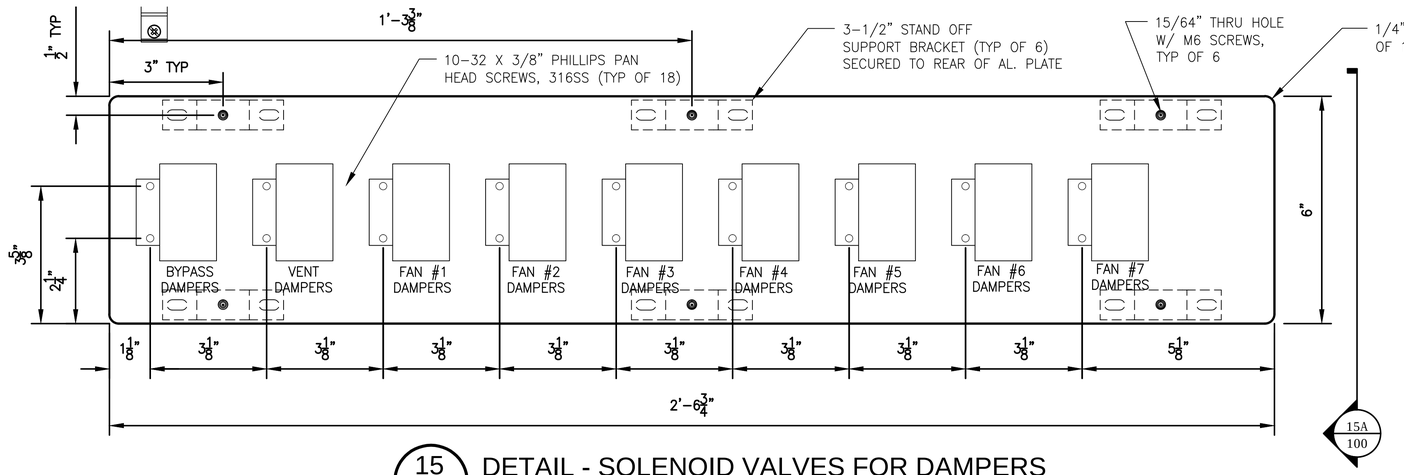
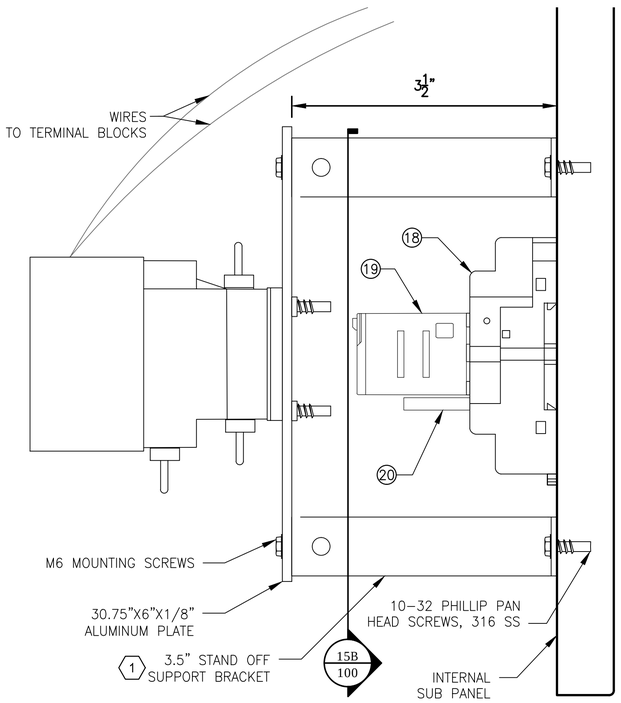
MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	7 of 42



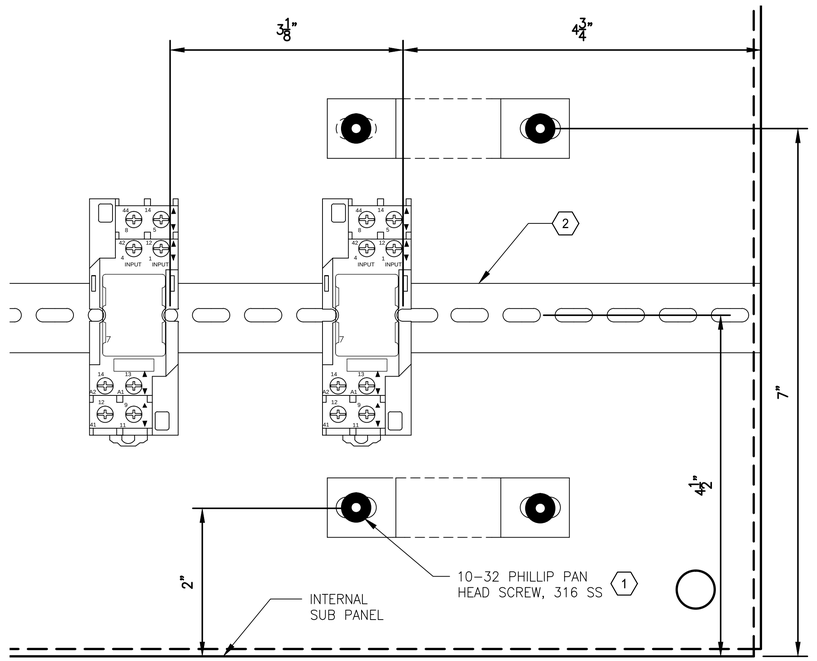
15 / 3/100 DETAIL - SOLENOID VALVES FOR DAMPERS

SCALE: 6" = 1'-0"



15A / 100 SECTION

SCALE: 1" = 1'-0"



15B / 100 SECTION

SCALE: 1" = 1'-0"

GENERAL NOTES:

1. ALL (#) REFER TO ITEMS IN THE CONTROL PANEL EQUIPMENT SCHEDULE ON DRAWING SHEET 2 OR 3.
2. CONTROL PANEL SHALL RECEIVE BOTH THE PNEUMATIC AIR VALVES AND ELECTRICAL RELAYS AS TO BE FORWARD COMPATIBLE WITH FAN SHAFT NEEDS.

(#) NOTES:

1. EACH 3.5" STAND OFF SHALL BE SECURED TO THE ENCLOSURE INTERNAL SUB PANEL BY #10-32 SCREWS IN TAPPED HOLES. NO MOUNTING HARDWARE IS TO BE ON REAR SIDE OF INTERNAL SUB PANEL.
2. EACH DIN RAIL SEGMENT SHALL BE SECURED TO THE INTERNAL SUB PANEL BY #10-32 MACHINE SCREWS IN TAPPED HOLES. EACH SCREW SHALL BE EQUIPPED WITH 0.75" OD FENDER WASHER. NO MOUNTING HARDWARE IS TO BE ON REAR SIDE OF INTERNAL SUB PANEL.

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DATE

APPROVED
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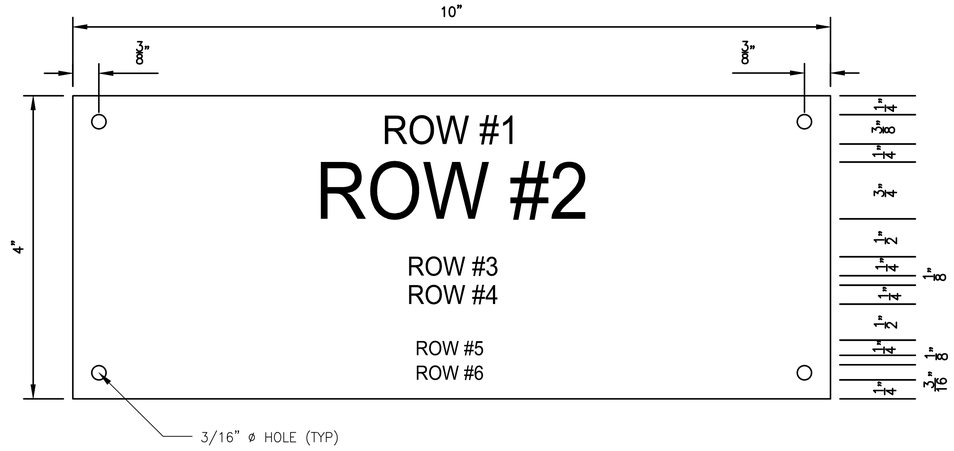
DEPUTY CHIEF ENGINEER
DATE

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	8 of 42

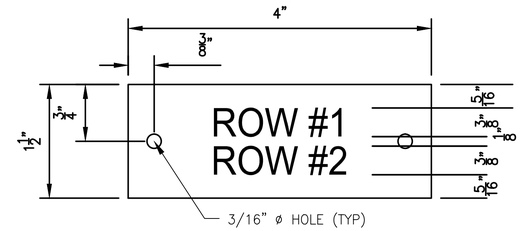


1A / 100 TYPE 1 IDENTIFICATION PLACARD

SCALE: 1" = 1"

GENERAL NOTES:

1. IDENTIFICATION PLACARD(S) SHALL BE ENGRAVED FROM 1/8" THICK ACRYLIC MATERIAL.
2. IDENTIFICATION PLACARD(S) SHALL BE BLACK CORE WITH WHITE GLOSSY SURFACE. FINAL APPEARANCE WILL BE BLACK TEXT ON WHITE BACKGROUND.
3. TEXT FONT SHALL BE ARIAL TYPE.
4. TEXT ON EACH PLACARD SHALL BE CENTERED HORIZONTALLY ON EACH ROW/ELEVATION DEPICTED ON THE DETAILS.
5. ONLY SQUARE OR BALL END TYPE MILLING BITS SHALL BE USED. NO V GROOVE BITS TO AVOID DIRT HOLDING ONCE INSTALLED.
6. IDENTIFICATION PLACARDS FOR ENCLOSURES AND EQUIPMENT SHALL HAVE SEALING WASHERS ON THE INTERIOR OF THE RESPECTIVE ENCLOSURE IN ORDER TO MAINTAIN THE ENCLOSURE NEMA RATING.
7. SEE NEXT THREE DRAWING SHEETS FOR PLACARD CONTINUATION AND SCHEDULE.



3A / 100 TYPE 2 IDENTIFICATION PLACARD

SCALE: 1" = 1"

FAN SHAFT ID:

FA14

Serving the A-Route tunnel between
Medical Center Station and the portal at 495

This sytem must remain in "Remote Control"
at all times except for maintenance and testing

2A / 100 EXAMPLE OF TYPE 1 PLACARD

SCALE: 1" = 1"

REMOTE CONTROL

4A / 100 EXAMPLE OF TYPE 2 PLACARD

SCALE: 1" = 1"

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DEPUTY CHIEF ENGINEER

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PLC CONTROL AND SEQUENCE OF OPERATION

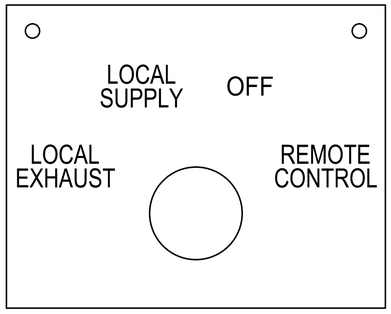
CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	9 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\MECH\PLC PANEL LAYOUT\CAD\ST-ME-FAN-100 ID PLACARD.DWG
Plotted by: E011967 Date: Thu, 24 Mar 2016 Time: 04:14:29 pm
Xrefs: ; .\FAN PLC PANEL.dwg
Images: ; DC_Architect.jpg ; DC_Engineer.jpg ; MARYLAND_ARCHITECT.jpg ; MARYLAND_ENGINEER.jpg ; Virginia_Architect.jpg ; Virginia_Engineer.jpg ; N:\ROBINSON-ELECT-MECH\MECH\CAD Standard\DWG BLOCKS\Bor

IDENTIFICATION PLACARD SCHEDULE									
QTY	TYPE	ROW #1 TEXT	ROW #2 TEXT	ROW #3 TEXT	ROW #4 TEXT	ROW #5 TEXT	ROW #6 TEXT	ROW #7 TEXT	NOTES
1	1	FAN SHAFT ID:	FA14	Serving the A–Route tunnel between	Medical Center Station and the portal at 495	This system must remain in "Remote Control"	at all times except for maintenance and testing		1,2,3,4
1	2	LOCAL	EXHAUST						1,3,4
1	2	LOCAL	SUPPLY						1,3,4
1	2	REMOTE	CONTROL						1,3,4
1	3	LOCAL	SUPPLY	OFF	LOCAL	EXHAUST	REMOTE	CONTROL	1,3,4

NOTE:
1. TEXT SHOWN AS DESIRED TO BE ENGRAVED ON PLACARD (UPPER/LOWER CASE) RESPECTIVELY.
2. FAN SHAFT ID SHALL BE IN THE FORMAT OF THE FOLLOWING "FA8" OR "FD13" FOR EXAMPLE. NO DASHES, ZERO'S, OR SPACES SHALL BE PROVIDED IN THE SITE ID'S.
3. REFER TO THE CONTROL PANEL DESIGN DRAWING SHEET 2 FOR PLACEMENT OF THE IDENTIFICATION PLACARDS.
4. THE PLACARDS SHALL BE ATTACHED TO THE CONTROL PANEL DOOR BY MEANS OF STAINLESS STEEL 10–32 MACHINE SCREWS AND VIBRATION PROOF LOCKNUTS. NEOPRENE SEALING WASHERS SHALL BE INSTALLED ON THE INSIDE OF THE PANEL TO RETAIN THE ENCLOSURES NEMA RATING.

1B / 100 TYPE 3 IDENTIFICATION PLACARD
SCALE: 1" = 1"



2B / 100 EXAMPLE OF TYPE 3 PLACARD
SCALE: 1" = 1"

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FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	10 of 42

IDENTIFICATION PLACARD SCHEDULE

ITEM	QTY	TYPE	ROW #1 TEXT	ROW #2 TEXT	ROW #3 TEXT	ROW #4 TEXT	ROW #5 TEXT	ROW #6 TEXT	NOTES
1	1	1	FAN SHAFT ID:	FA1	Serving the A-Route tunnel between	Metro Center Upper Level and Farragut North Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
2	1	1	FAN SHAFT ID:	FA2	Serving the A-Route tunnel between	Farragut North, A and C Route connector, and Metro Center Upper Level	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
3	1	1	FAN SHAFT ID:	FA3	Serving the A-Route tunnel between	Farragut North and Dupont Circle Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
4	1	1	FAN SHAFT ID:	FA4	Serving the A-Route tunnel between	Dupont Circle and Woodly Park Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
5	1	1	FAN SHAFT ID:	FA5	Serving the A-Route tunnel between	Woodly Park and Dupont Circle Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
6	1	1	FAN SHAFT ID:	FA6	Serving the A-Route tunnel between	Woodly Park and Cleveland Park Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
7	1	1	FAN SHAFT ID:	FA9	Serving the A-Route tunnel between	Tenlytown and Van Ness Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
8	1	1	FAN SHAFT ID:	FA10	Serving the A-Route tunnel between	Tenlytown and Friendship Heights Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
9	1	1	FAN SHAFT ID:	FA11	Serving the A-Route tunnel between	Friendship Heights and Bethesda Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
10	1	1	FAN SHAFT ID:	FA12	Serving the A-Route tunnel between	Bethesda and Friendship Heights Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
11	1	1	FAN SHAFT ID:	FA15	Serving the A-Route tunnel between	Grosvenor-Strathmore and White Flint Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
12	1	1	FAN SHAFT ID:	FA16	Serving the A-Route tunnel between	White Flint Station and the portal inbound from Twinbrook Station	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
13	1	1	FAN SHAFT ID:	FB1	Serving the B-Route tunnel between	Metro Center Upper Level and Gallery Place Upper Level Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
14	1	1	FAN SHAFT ID:	FB3	Serving the B-Route tunnel between	Judiciary Square and Union Station	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
15	1	1	FAN SHAFT ID:	FB4	Serving the B-Route tunnel between	Union Station and Judiciary Square Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
16	1	1	FAN SHAFT ID:	FB5	Serving the B-Route tunnel between	the portal outbound of Silver Spring Station to Forest Glen Station	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
17	1	1	FAN SHAFT ID:	FB6	Serving the B-Route tunnel between	Forest Glen and Wheaton Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
18	1	1	FAN SHAFT ID:	FB7	Serving the B-Route tunnel between	Weaton and Forest Glen Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
19	1	1	FAN SHAFT ID:	FB8	Serving the B-Route tunnel between	Wheaton and Glenmont Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
20	1	1	FAN SHAFT ID:	FB9	Serving the B-Route tunnel between	Glenmont and Wheaton Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
21	1	1	FAN SHAFT ID:	FC1	Serving the C-Route tunnel between	Metro Center Lower Level and McPherson Square Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
22	1	1	FAN SHAFT ID:	FC3	Serving the C-Route tunnel between	Farragut West and Foggy Bottom Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
23	1	1	FAN SHAFT ID:	FC4	Serving the C-Route tunnel between	Foggy Bottom Station to Mid River	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
24	1	1	FAN SHAFT ID:	FC5	Serving the C-Route tunnel between	Mid River to Rosslyn Station	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
25	1	1	FAN SHAFT ID:	FC6	Serving the C-Route tunnel between	Rosslyn, the K-Route turn out, and the portal outbound of Rosslyn Station	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
26	1	1	FAN SHAFT ID:	FC7	Serving the C-Route tunnel between	the portal inbound of Pentagon Station and the L-Route turn out	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
27	1	1	FAN SHAFT ID:	FC8	Serving the C-Route tunnel between	Pentagon and Pentagon City Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
28	1	1	FAN SHAFT ID:	FC9	Serving the C-Route tunnel between	Pentagon City and Crystal City Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
29	1	1	FAN SHAFT ID:	FC10	Serving the C-Route tunnel between	Potomac Yard Portal and Braddock Road Portal tunnel section under Slaters Lane and Route 1	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
30	1	1	FAN SHAFT ID:	FC11	Serving the C-Route tunnel between	Braddock Road Station, C and J Junction, and Eisenhower Ave Station	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
31	1	1	FAN SHAFT ID:	FC12	Serving the C-Route tunnel between	Huntington Station and the Outbound Storage track area	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
32	1	1	FAN SHAFT ID:	FD1	Serving the D-Route tunnel between	Metro Center Lower Level and Federal Triangle Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
33	1	1	FAN SHAFT ID:	FD3	Serving the D-Route tunnel between	Smithsonian Station and L'Enfant Plaza Lower Level	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
34	1	1	FAN SHAFT ID:	FD4	Serving the D-Route tunnel between	L'Enafant Plaza Lower Level and Federal Center South West Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
35	1	1	FAN SHAFT ID:	FD5	Serving the D-Route tunnel between	Federal Center South West and Capital South Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
36	1	1	FAN SHAFT ID:	FD6	Serving the D-Route tunnel between	Capital South and Eastern Market Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
37	1	1	FAN SHAFT ID:	FD7	Serving the D-Route tunnel between	Eastern Market and Potomac Ave Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
38	1	1	FAN SHAFT ID:	FD8	Serving the D-Route tunnel between	Potomac Ave and Stadium Armory Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4

NOTES:

1. TEXT SHOWN AS DESIRED TO BE ENGRAVED ON PLACARD (UPPER/LOWER CASE) RESPECTIVELY.
2. FAN SHAFT ID SHALL BE IN THE FORMAT OF THE FOLLOWING "FA8" OR "FD13" FOR EXAMPLE. NO DASHES, ZERO'S, OR SPACES SHOULD PROVIDED IN THE SITE ID.
3. REFER TO THE CONTROL PANEL DESIGN DRAWING SHEET 2 FOR PLACEMENT OF THE IDENTIFICATION PLACARDS.
4. THE PLACARDS SHALL BE ATTACHED TO THE CONTROL PANEL DOOR BY MEANS OF STAINLESS STEEL 10-32 MACHINE SCREWS AND VIBRATION PROOF LOCKNUTS. NEOPRENE SEALING WASHERS SHALL BE INSTALLED ON THE INSIDE OF THE PANEL TO RETAIN THE ENCLOSURE NEMA RATING.

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DRAWN Y. Liu 9-16-2015 DATE

CHECKED P. Petersen 9-24-2015 DATE

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NUMBER	TITLE

REVISIONS

DATE	NUM	DESCRIPTION
1/15/2016	1	100% DESIGN

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DEPARTMENT OF TRANSIT INFRASTRUCTURE AND ENGINEERING SERVICES
CENI - POWER SYSTEMS ENGINEERING

REVISION SUBMITTED _____ DATE

APPROVED _____ DATE
ASHTON ROBINSON
DEPUTY CHIEF ENGINEER

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	11 of 42

IDENTIFICATION PLACARD SCHEDULE

ITEM	QTY	TYPE	ROW #1 TEXT	ROW #2 TEXT	ROW #3 TEXT	ROW #4 TEXT	ROW #5 TEXT	ROW #6 TEXT	NOTES
39	1	1	FAN SHAFT ID:	FD9	Serving the D-Route tunnel between	Stadium Armory Station and the outbound portal near the RFK Stadium parking lot	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
40	1	1	FAN SHAFT ID:	FE1	Serving the E-Route tunnel between	Gallery Place Lower Level and Mt. Vernon Square Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
41	1	1	FAN SHAFT ID:	FE2	Serving the E-Route tunnel between	Mt. Vernon and Shaw-Howard University Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
42	1	1	FAN SHAFT ID:	FE3	Serving the E-Route tunnel between	Shaw-Howard University and U Street Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
43	1	1	FAN SHAFT ID:	FE5	Serving the E-Route tunnel between	U Street and Columbia Heights Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
44	1	1	FAN SHAFT ID:	FE6	Serving the E-Route tunnel between	Columbia Heights and Georgia Ave-Petworth Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
45	1	1	FAN SHAFT ID:	FE8	Serving the E-Route tunnel between	Fort Totten and Georgia Ave-Petworth Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
46	1	1	FAN SHAFT ID:	FE9	Serving the E-Route tunnel between	Fort Totten Station, E and B Route connector, and the Portal Inbound from West Hyattsville Station	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
47	1	1	FAN SHAFT ID:	FE10	Serving the E-Route tunnel between	West Hyattsville and P.G. Plaza Stations tunnel section under Ager Road	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
48	1	1	FAN SHAFT ID:	FE11	Serving the E-Route tunnel between	West Hyattsville and P.G. Plaza Stations tunnel section just inbound of P.G. Plaza Station	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
49	1	1	FAN SHAFT ID:	FE12	Serving the E-Route tunnel between	P.G. Plaza and College Park Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
50	1	1	FAN SHAFT ID:	FE13	Serving the E-Route tunnel between	College Park and P.G. Plaza Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
51	1	1	FAN SHAFT ID:	FF2	Serving the F-Route tunnel between	Archives Station and L'Enfant Plaza Upper Level	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
52	1	1	FAN SHAFT ID:	FF3	Serving the F-Route tunnel between	L'Enfant Plaza Upper Level and Waterfront Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
53	1	1	FAN SHAFT ID:	FF4	Serving the F-Route tunnel between	Waterfront and Navy Yard Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
54	1	1	FAN SHAFT ID:	FF5	Serving the F-Route tunnel between	Navy Yard and Anacostia Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
55	1	1	FAN SHAFT ID:	FF6	Serving the F-Route tunnel between	Anacostia and Congress Heights Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
56	1	1	FAN SHAFT ID:	FF7	Serving the F-Route tunnel between	Congress Heights and Anacostia Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
57	1	1	FAN SHAFT ID:	FF8	Serving the F-Route tunnel between	Congress Heights and Southern Ave Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
58	1	1	FAN SHAFT ID:	FF9	Serving the F-Route tunnel between	Southern Ave and Naylor Road Stations short tunnel section by 23rd Parkway	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
59	1	1	FAN SHAFT ID:	FF10	Serving the F-Route tunnel between	Suitland and Branch Ave Stations short tunnel section	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
60	1	1	FAN SHAFT ID:	FK1	Serving the K-Route tunnel between	Rosslyn, the C-Route turn out, and Court House Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
61	1	1	FAN SHAFT ID:	FK2	Serving the K-Route tunnel between	Court House and Clarendon Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
62	1	1	FAN SHAFT ID:	FK3	Serving the K-Route tunnel between	Clarendon and Virginia Square Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
63	1	1	FAN SHAFT ID:	FK4	Serving the K-Route tunnel between	Virginia Square and Ballston Stations	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
64	1	1	FAN SHAFT ID:	FK5	Serving the K-Route tunnel between	Ballston and the outbound portal near I-66	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
65	1	1	FAN SHAFT ID:	FL2	Serving the L-Route tunnel between	the portal at GW Parkway and Pentagon Station	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
66	1	1	FAN SHAFT ID:				This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4,5
67	1	1	FAN SHAFT ID:				This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4,5
68	1	1	FAN SHAFT ID:				This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4,5
69	1	1	FAN SHAFT ID:				This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4,5
70	1	1	FAN SHAFT ID:				This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4,5
71	1	1	FAN SHAFT ID:	FA14	Serving the A-Route tunnel between	Medical Center Station and the portal at I-495	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4
72	1	1	FAN SHAFT ID:	FA14	Serving the A-Route tunnel between	Medical Center Station and the portal at I-495	This system must remain in "Remote Control"	at all times except for maintenance and testing	1,2,3,4

NOTES:

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5. TEXT CELLS THAT CONTAIN NO TEXT SHALL BE LEFT BLANK DUE TO THESE CONTROL PANELS BEING SPARES WITH NO ASSIGNED LOCATION FOR INSTALL.

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EXPIRATION DATE: _____

- COMAR 09.23.03.10

DESIGNED C. Lesefske 9-4-2015 DATE
DRAWN Y. Liu 9-16-2015 DATE
CHECKED P. Petersen 9-24-2015 DATE

REFERENCE DRAWINGS

NUMBER	TITLE

REVISIONS

DATE	NUM	DESCRIPTION
1/15/2016	1	100% DESIGN

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

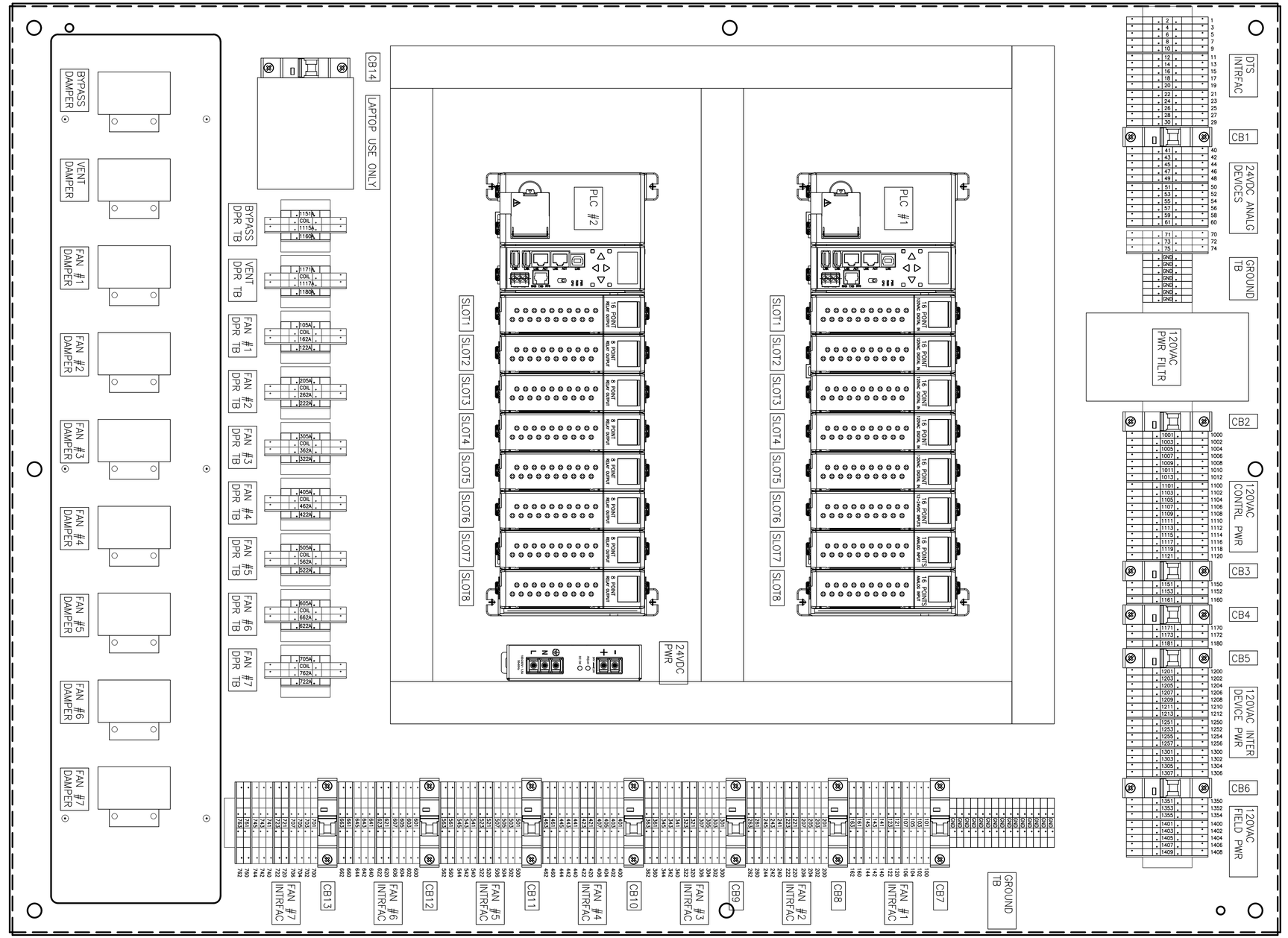
DEPARTMENT OF TRANSIT INFRASTRUCTURE AND ENGINEERING SERVICES
CENI - POWER SYSTEMS ENGINEERING

REVISION SUBMITTED _____ DATE

APPROVED _____ DATE
ASHTON ROBINSON
DEPUTY CHIEF ENGINEER

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	12 of 42



GENERAL NOTES:

1. INTERNAL DEVICES AND TERMINAL BLOCKS SHALL RECEIVE ADHESIVE BACKED LABELS AS DENOTED. SEE GENERAL NOTE #7 ON SHEET #1 FOR ADDITIONAL REQUIREMENTS.

3A / 100 COMPONENT LABELS OF CONTROL PANEL

SCALE: 6" = 1'-0"

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PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	13 of 42

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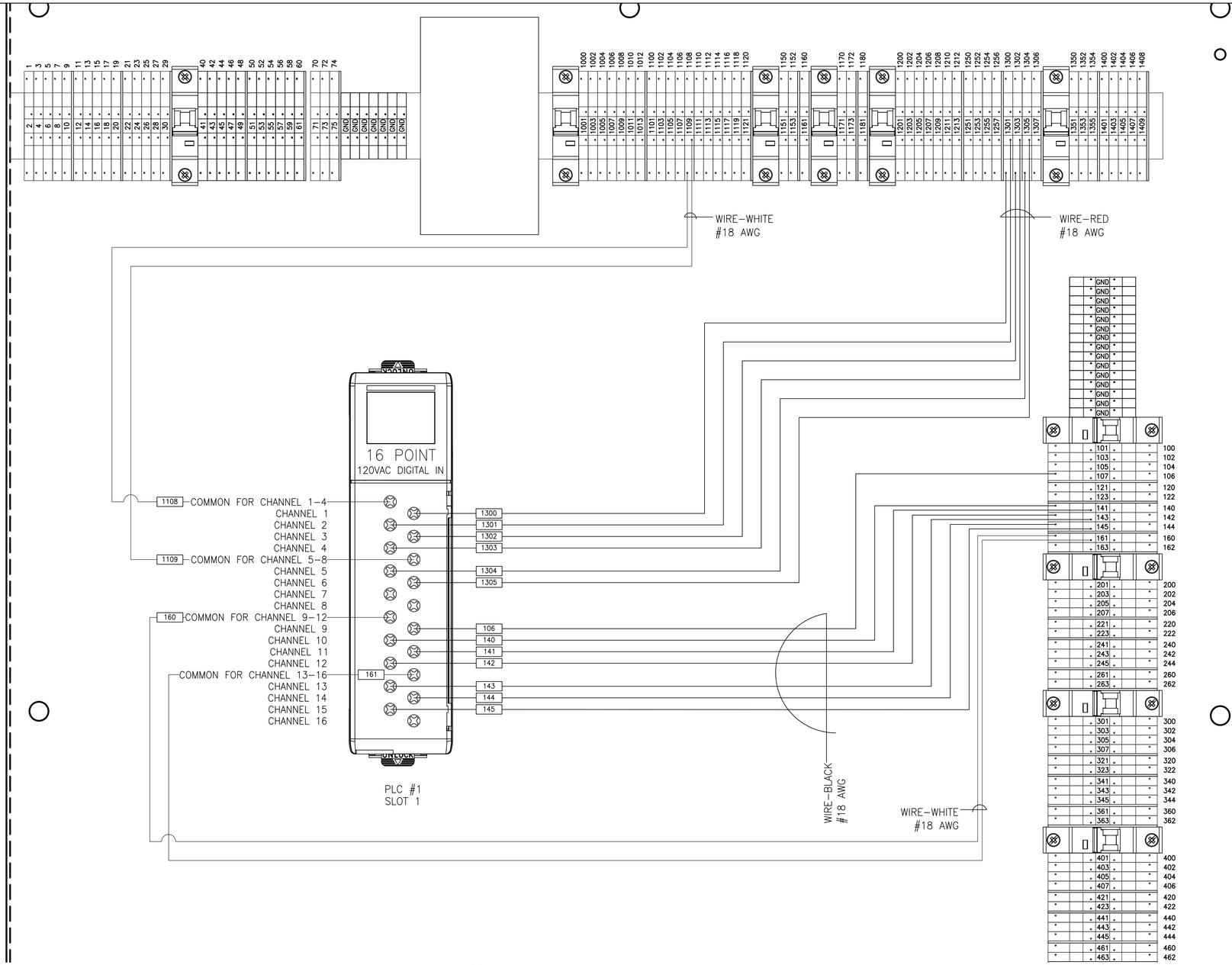
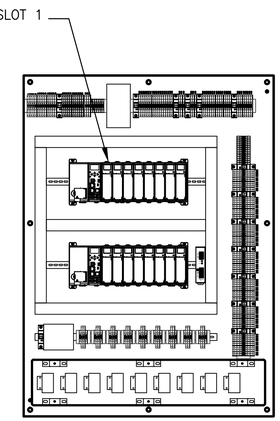


4.1 / 100 PLC #1 SLOT 1 WIRING DIAGRAM

SCALE: NTS

GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.



KEY PLAN

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MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	14 of 42

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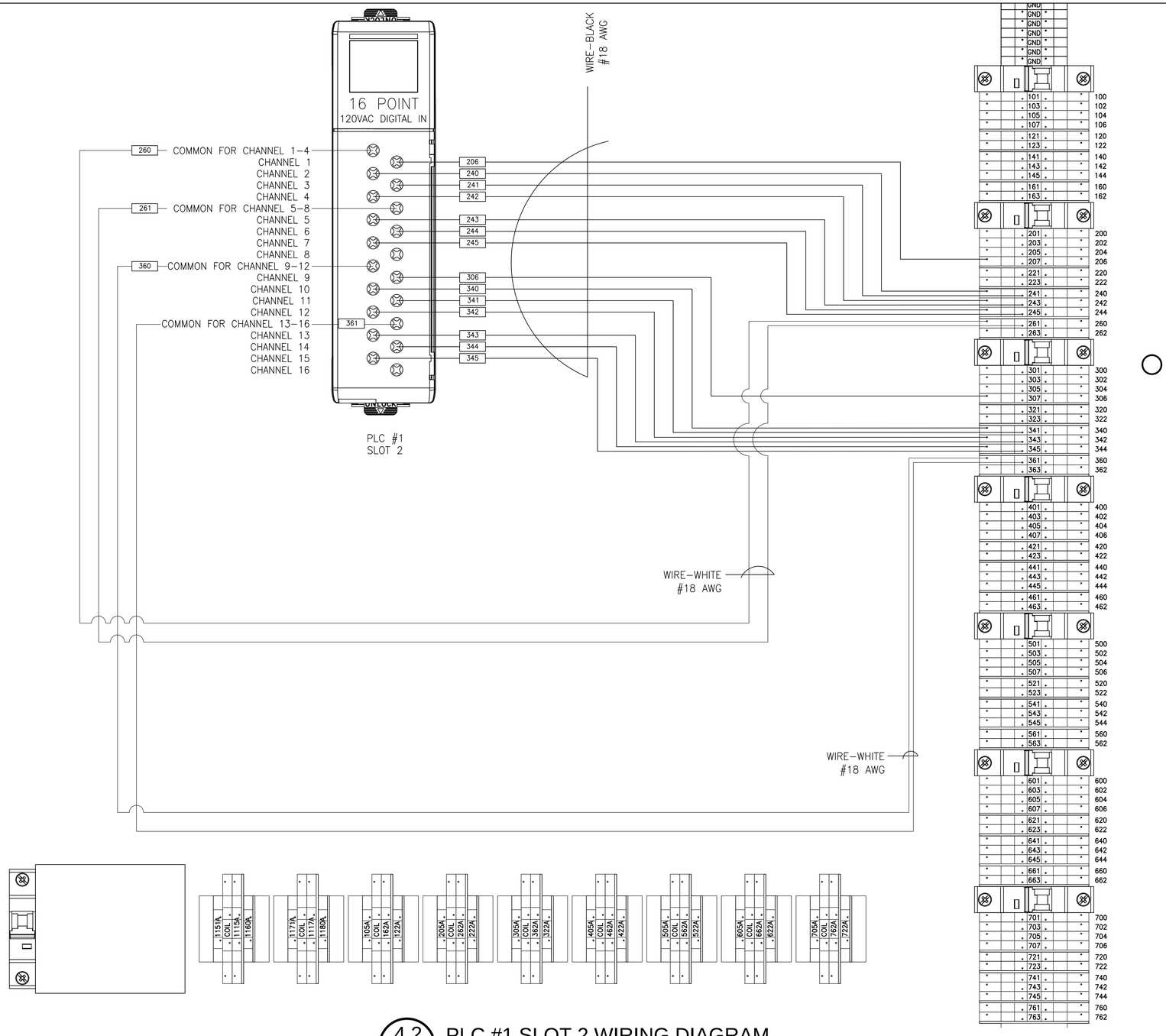
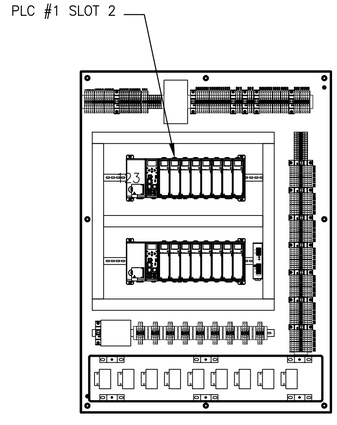


4.2 / 100 PLC #1 SLOT 2 WIRING DIAGRAM

SCALE: NTS

GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.



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PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	15 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
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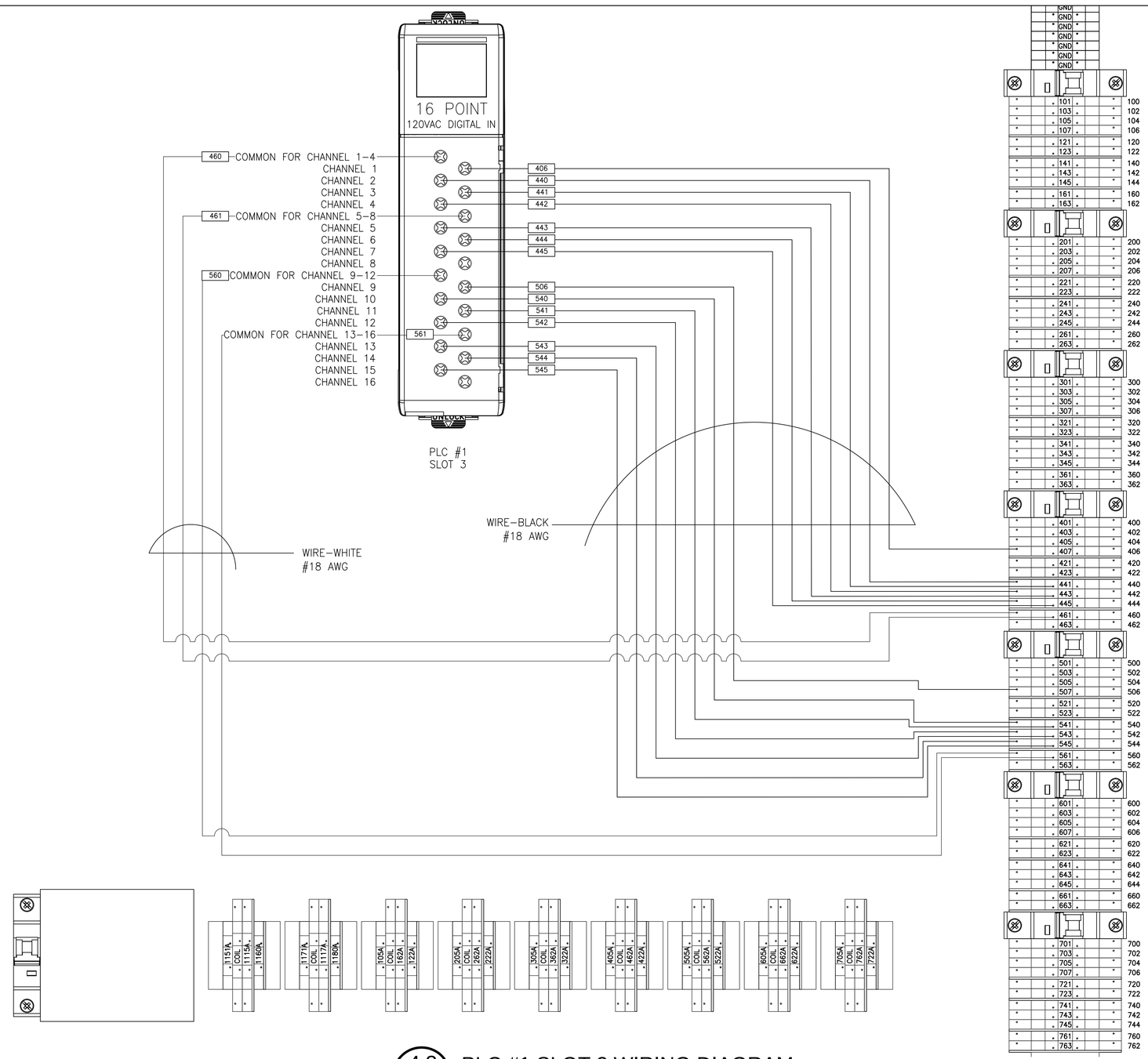
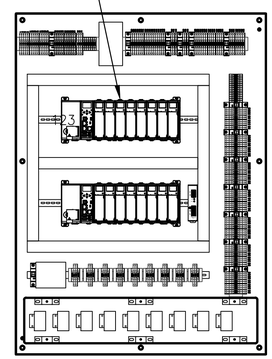


4.3 / 100 PLC #1 SLOT 3 WIRING DIAGRAM

SCALE: NTS

GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.



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WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DEPARTMENT OF TRANSIT INFRASTRUCTURE AND ENGINEERING SERVICES
CENI - POWER SYSTEMS ENGINEERING

REVISION SUBMITTED _____ DATE

APPROVED _____ DATE
ASHTON ROBINSON
DEPUTY CHIEF ENGINEER

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	16 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
Plotted by: E01967 Date: Thu, 24 Mar 2016 Time: 04:15:53 pm
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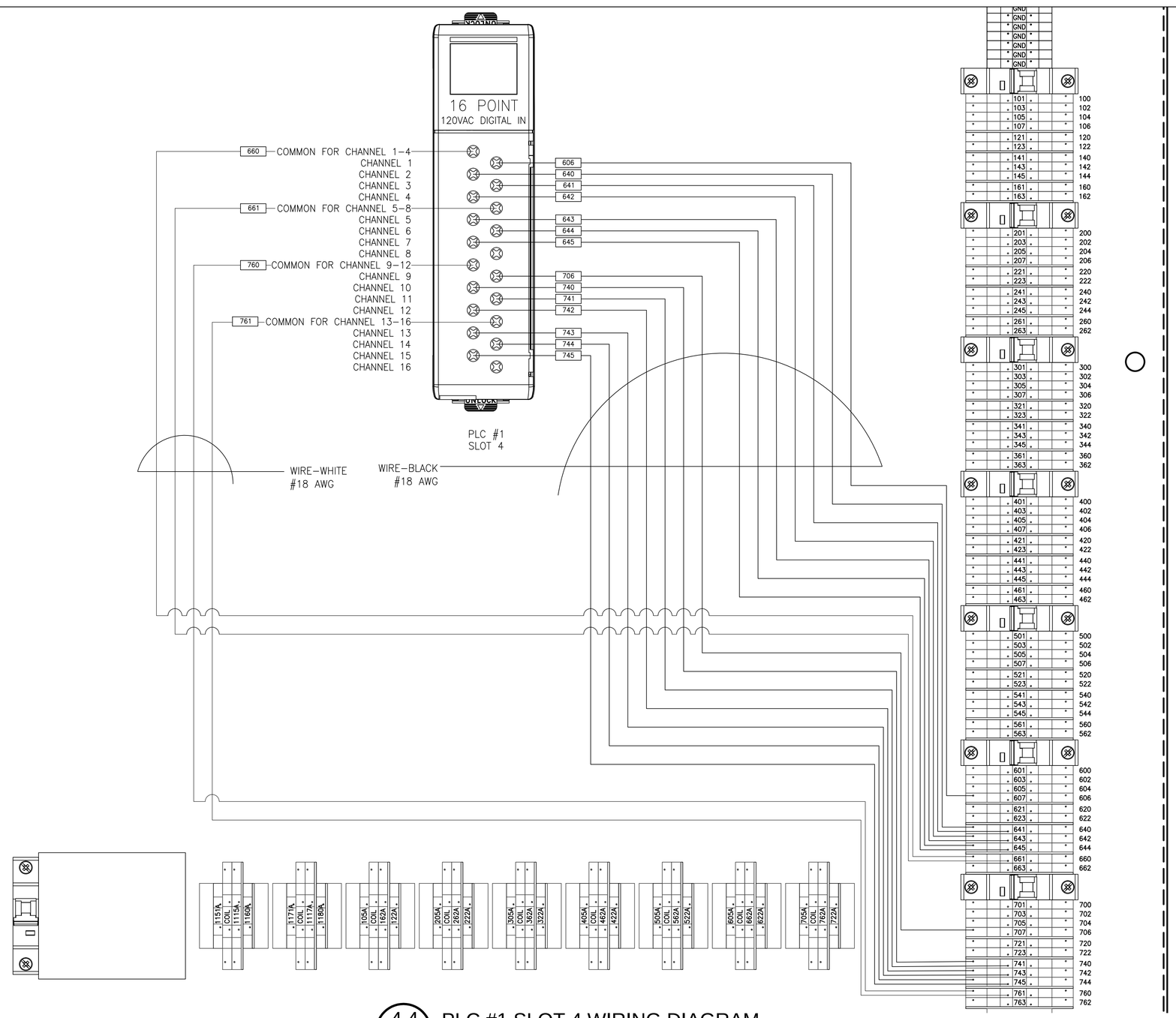
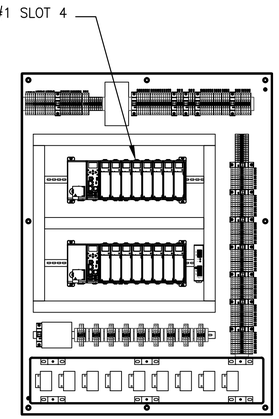


4.4 / 100 PLC #1 SLOT 4 WIRING DIAGRAM

SCALE: NTS

GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.



KEY PLAN

"PROFESSIONAL CERTIFICATION: I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND."

LICENSE No. _____

EXPIRATION DATE: _____

- COMAR 09.23.03.10

DESIGNED	C. Lesefske	9-4-2015 DATE
DRAWN	Y. Liu	9-16-2015 DATE
CHECKED	P. Petersen	9-24-2015 DATE

REFERENCE DRAWINGS

NUMBER	TITLE

REVISIONS

DATE	NUM	DESCRIPTION
1/15/2016	1	100% DESIGN

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PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	17 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
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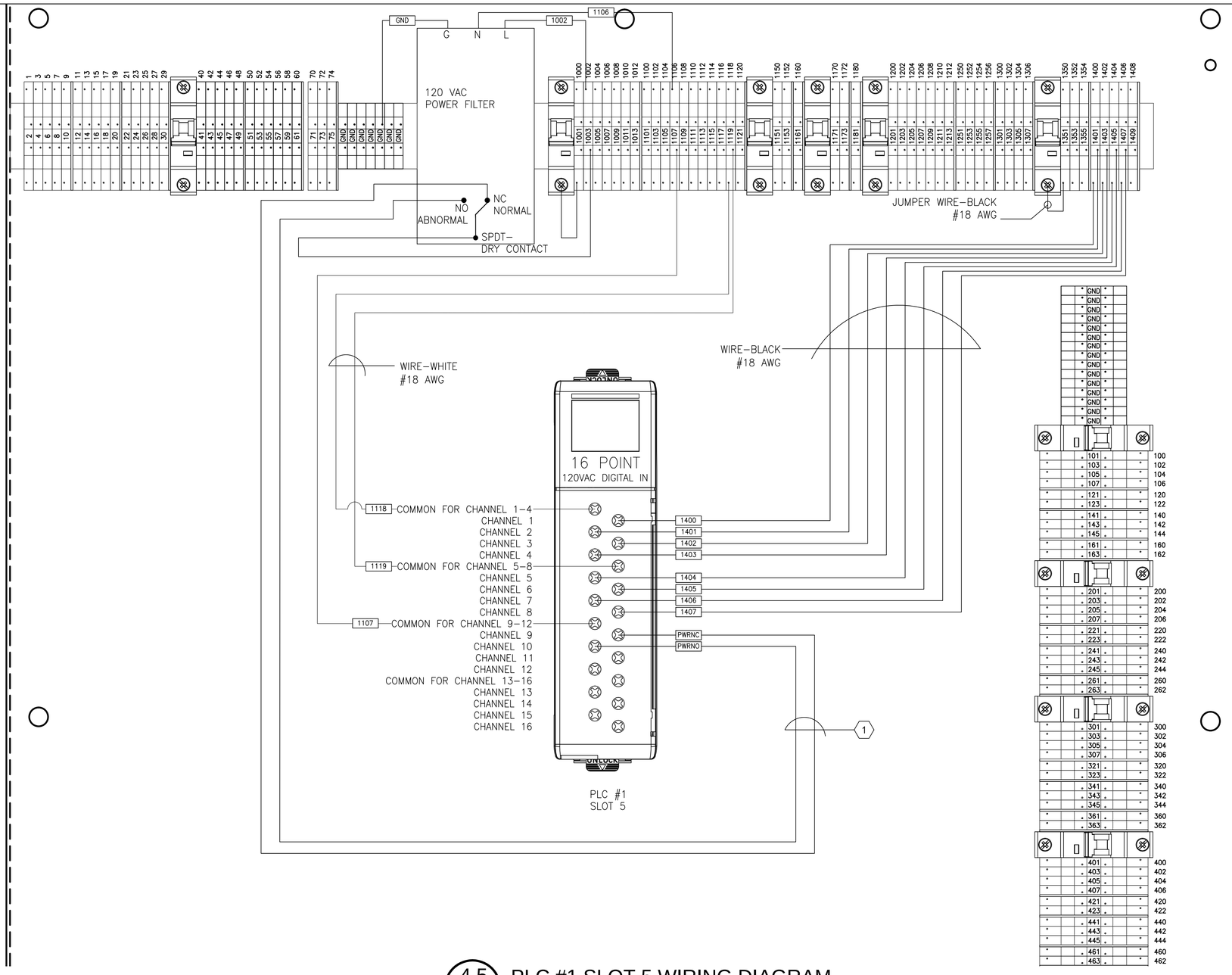


4.5 / 100 PLC #1 SLOT 5 WIRING DIAGRAM

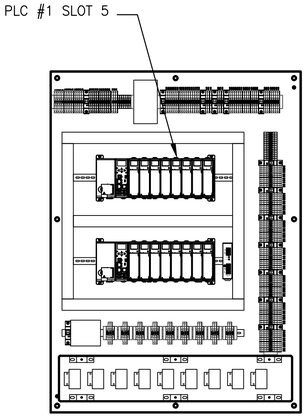
SCALE: NTS

GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.

(#) NOTES:

1. THE WIRE LEAD LENGTH ON THE SURGE ARRESTOR SHALL BE OF SUFFICIENT LENGTH AS TO BE RAN CONTINUOUS, WITHOUT EXTENSION TO THE PLC MODULE.



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DEPUTY CHIEF ENGINEER

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TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	18 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
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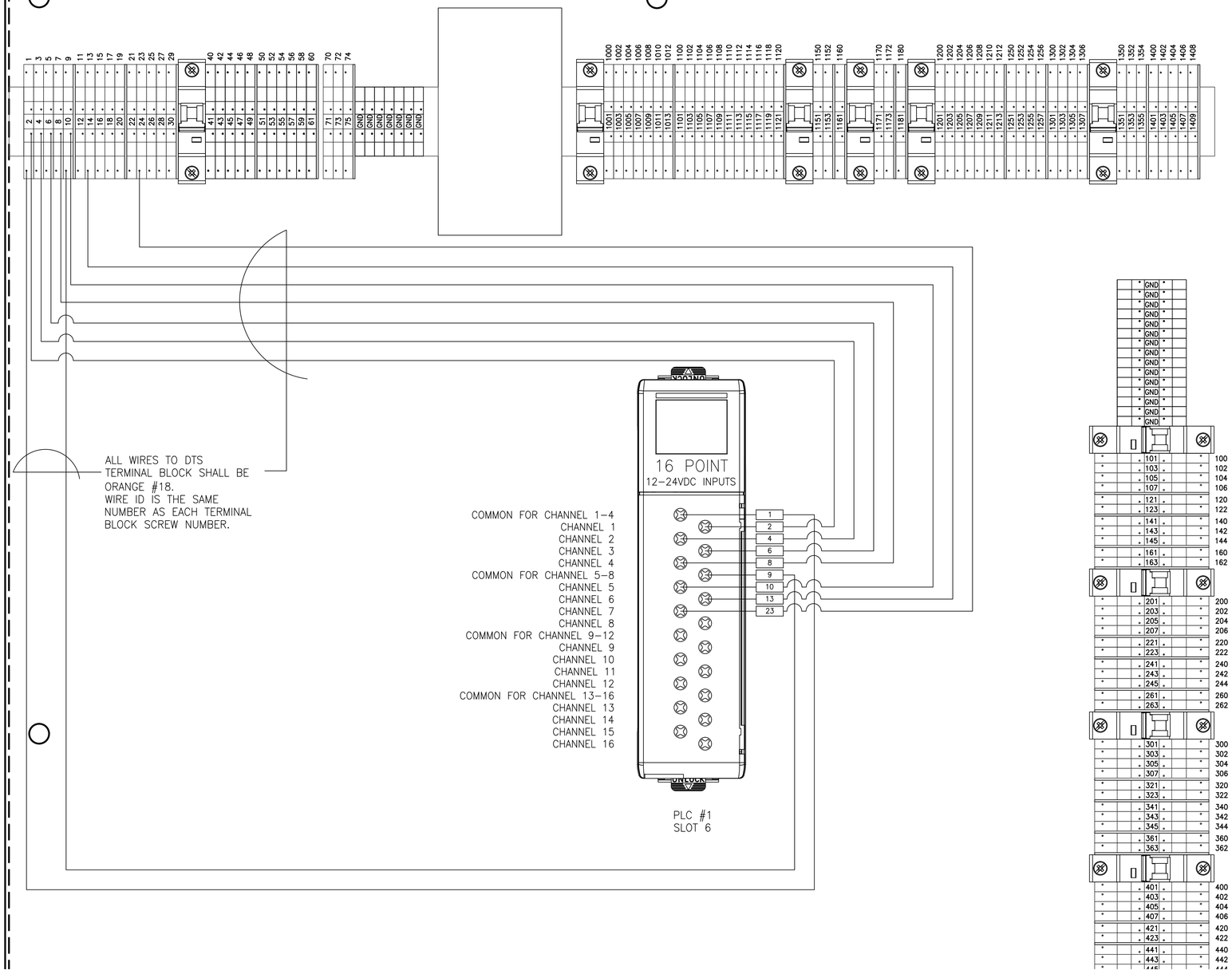
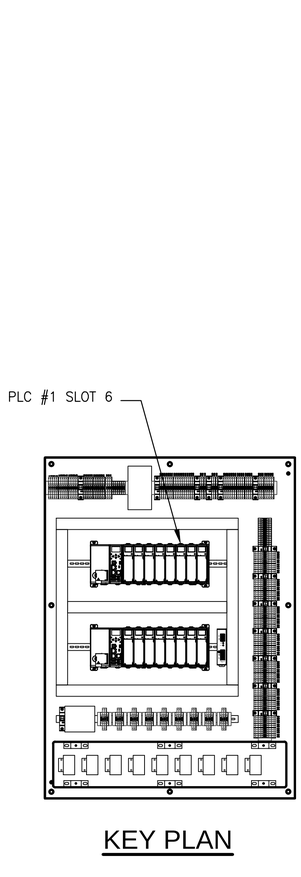


GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.



KEY PLAN

4.6 / 100 PLC #1 SLOT 6 WIRING DIAGRAM

SCALE: NTS

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PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	19 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
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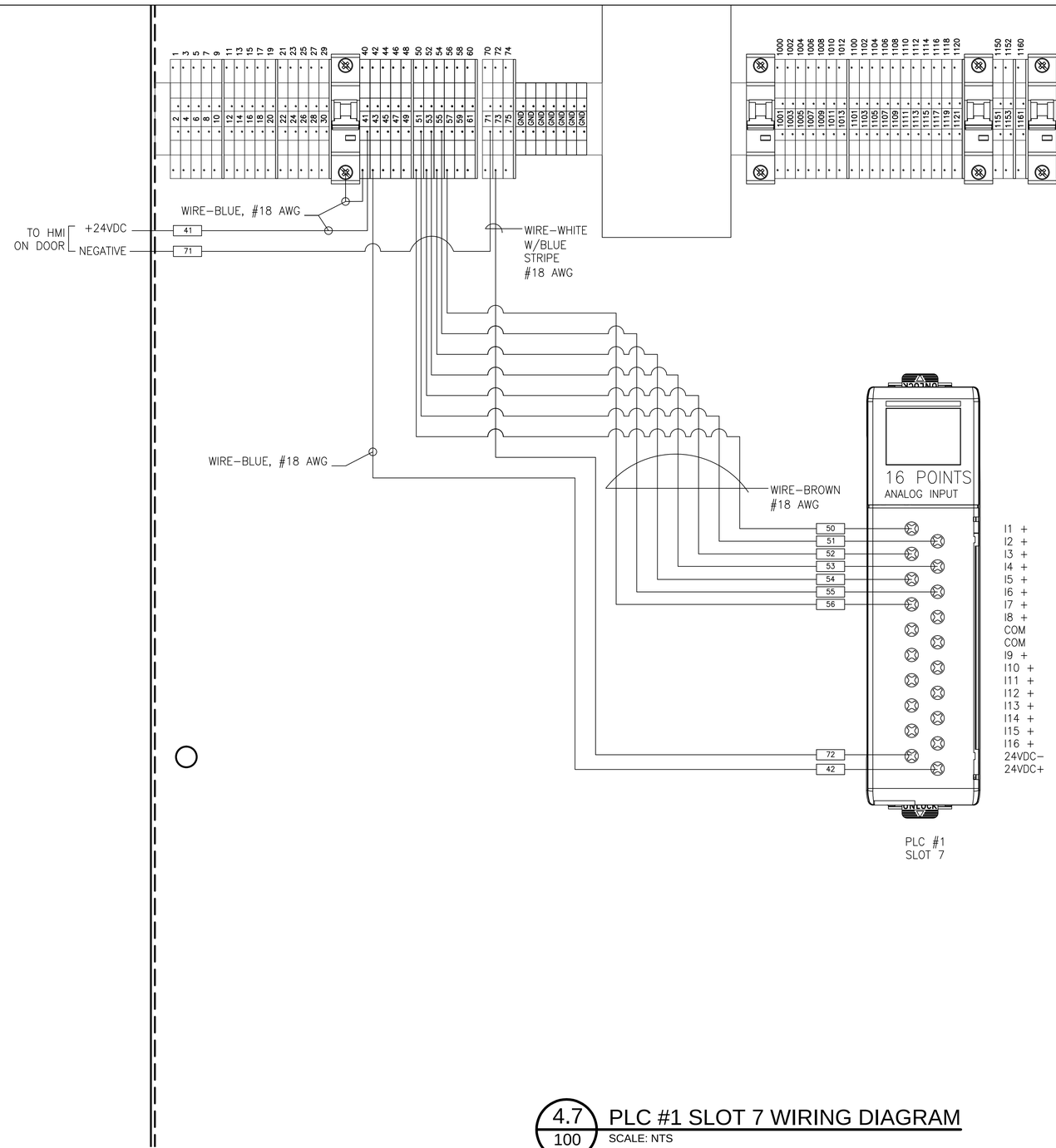
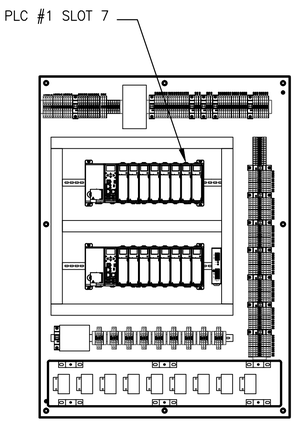


4.7 / 100 PLC #1 SLOT 7 WIRING DIAGRAM

SCALE: NTS

GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.
2. THE ROUTING OF COMMUNICATIONS AND ANALOG CABLING SHALL BE DISTANCED AS FAR AS PRACTICAL FROM 120VAC OR 24VDC POWER CIRCUITS.



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PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	20 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
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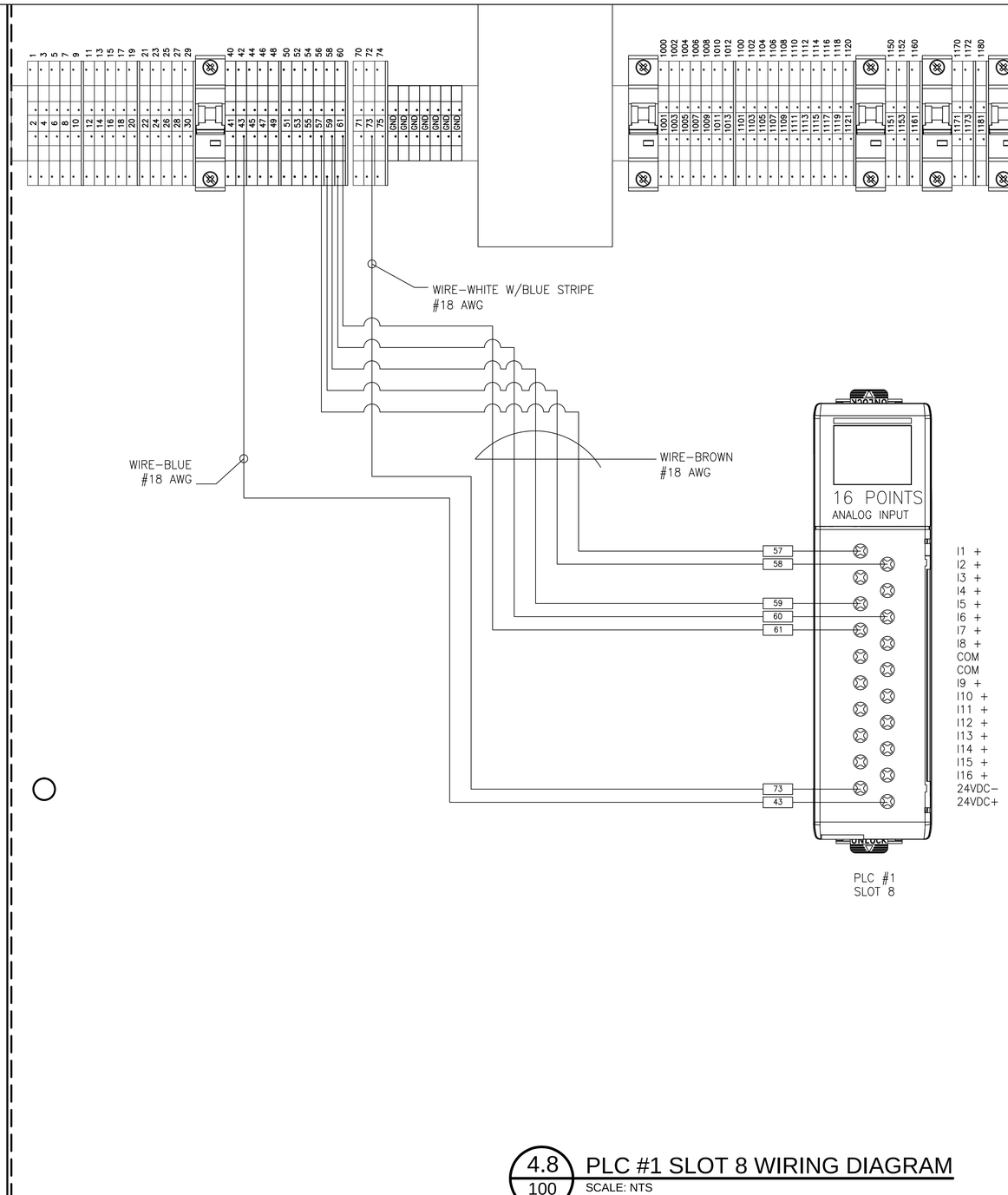
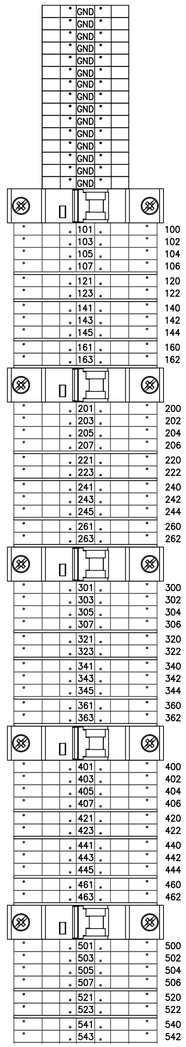


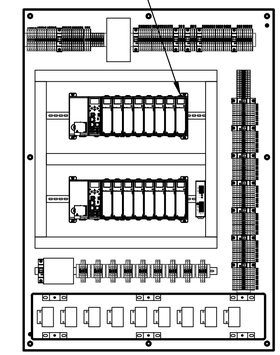


4.8 / 100 PLC #1 SLOT 8 WIRING DIAGRAM

SCALE: NTS

GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.



KEY PLAN

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WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

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ASHTON ROBINSON
DEPUTY CHIEF ENGINEER

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	21 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
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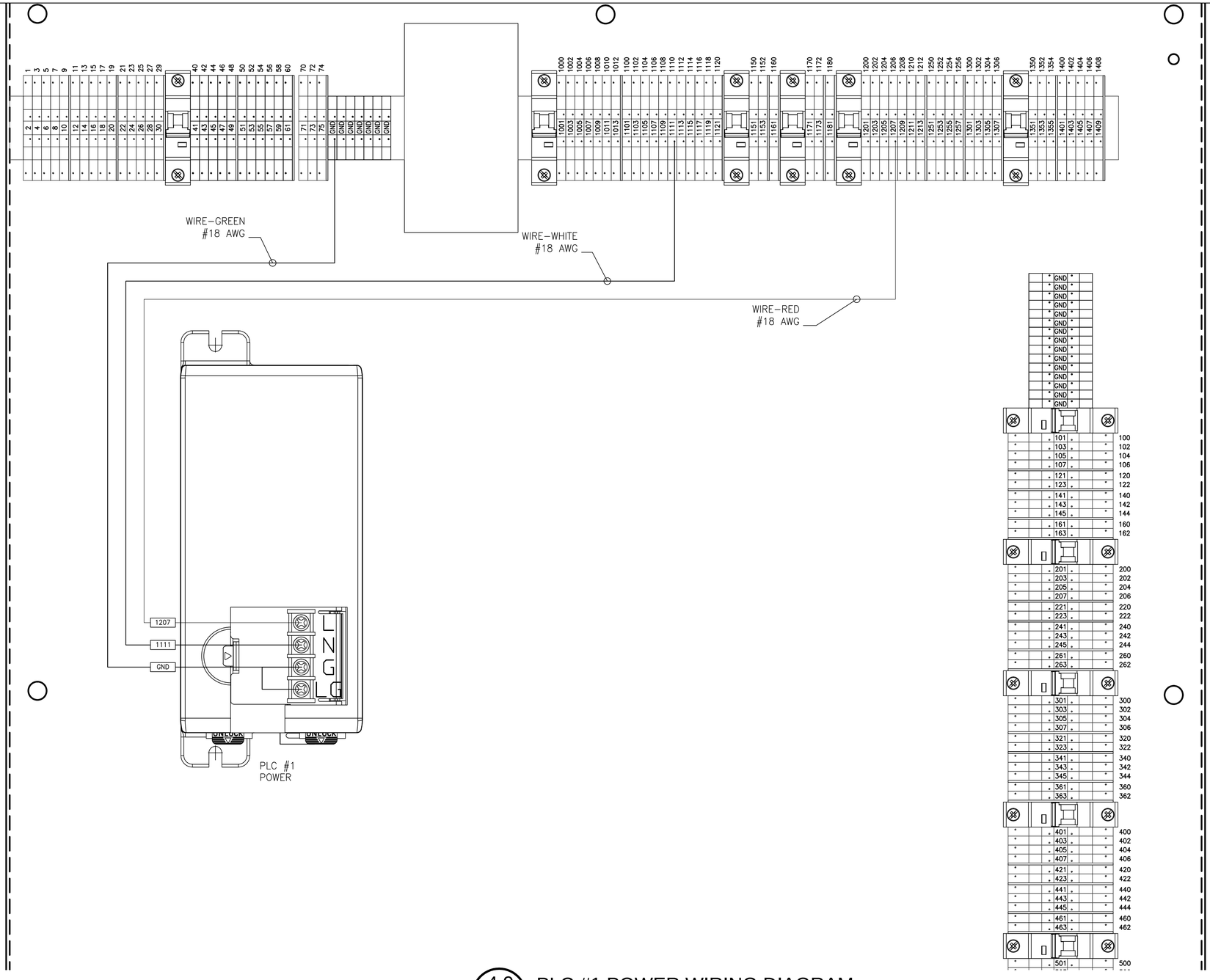
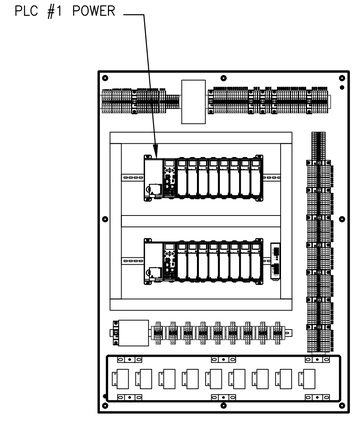


GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.



KEY PLAN

4.9 / 100 PLC #1 POWER WIRING DIAGRAM

SCALE: NTS

"PROFESSIONAL CERTIFICATION. I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND."

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PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	22 of 42

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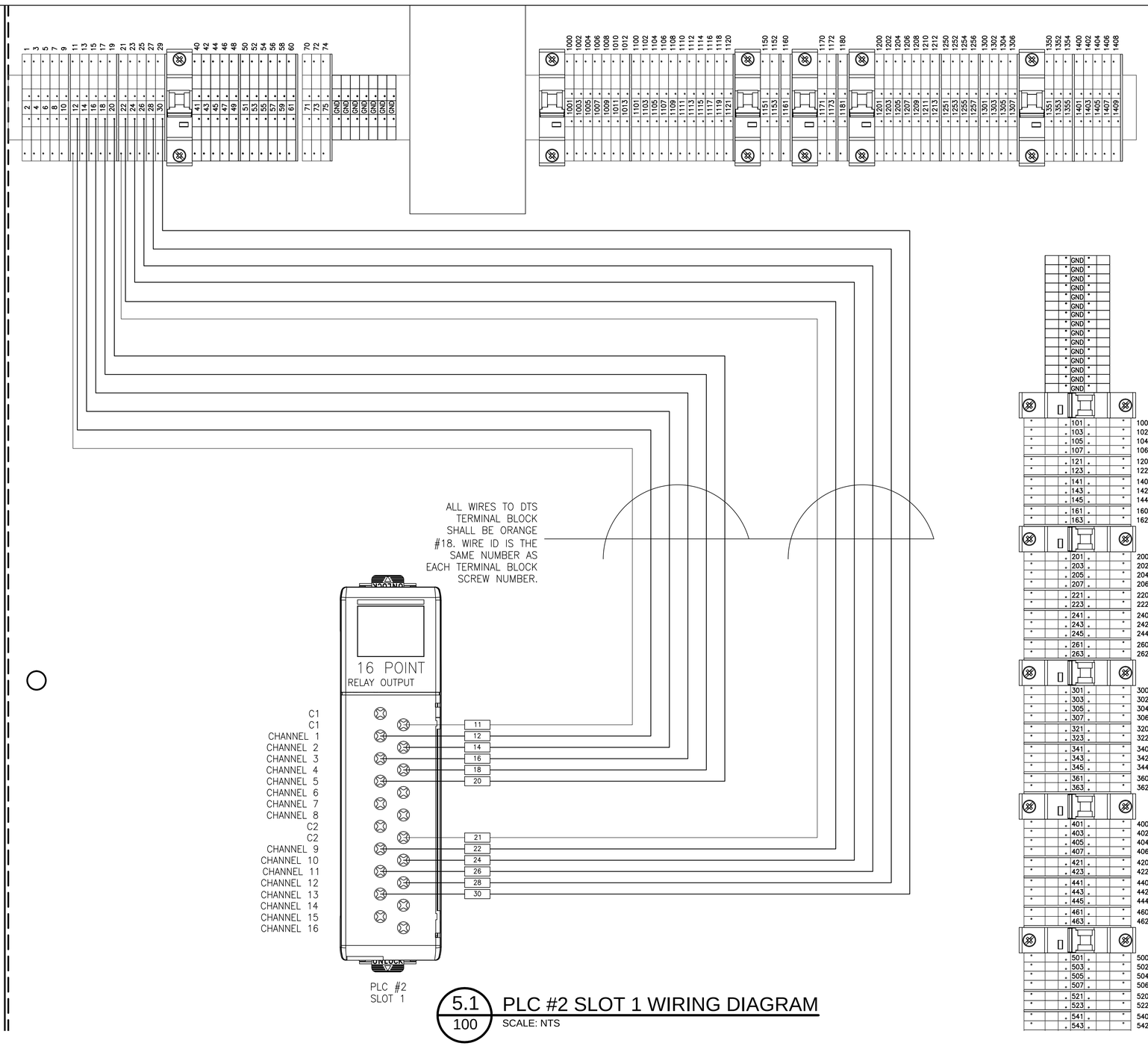
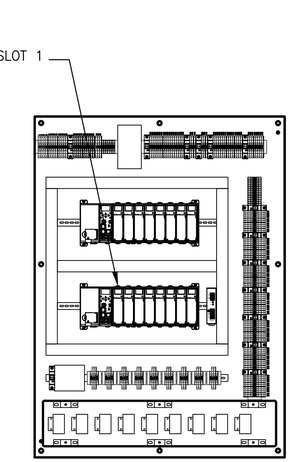


5.1 / 100 PLC #2 SLOT 1 WIRING DIAGRAM

SCALE: NTS

GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.



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FQ-	AS NOTED	ST-ME-FAN-100	23 of 42

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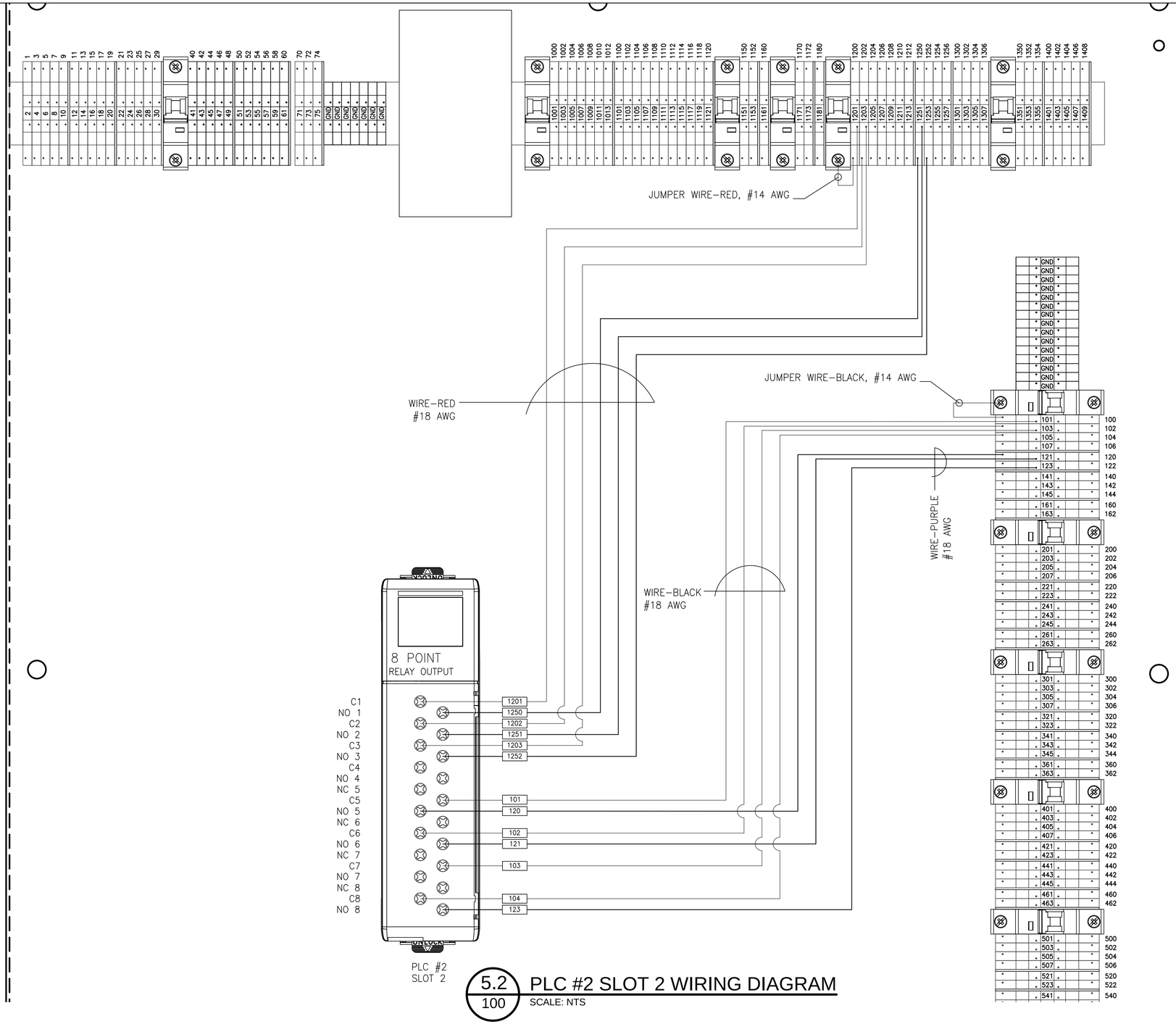
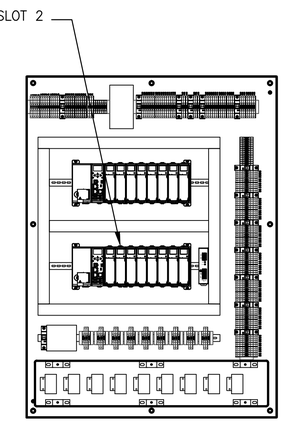


5.2 / 100 PLC #2 SLOT 2 WIRING DIAGRAM

SCALE: NTS

GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.



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CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	24 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
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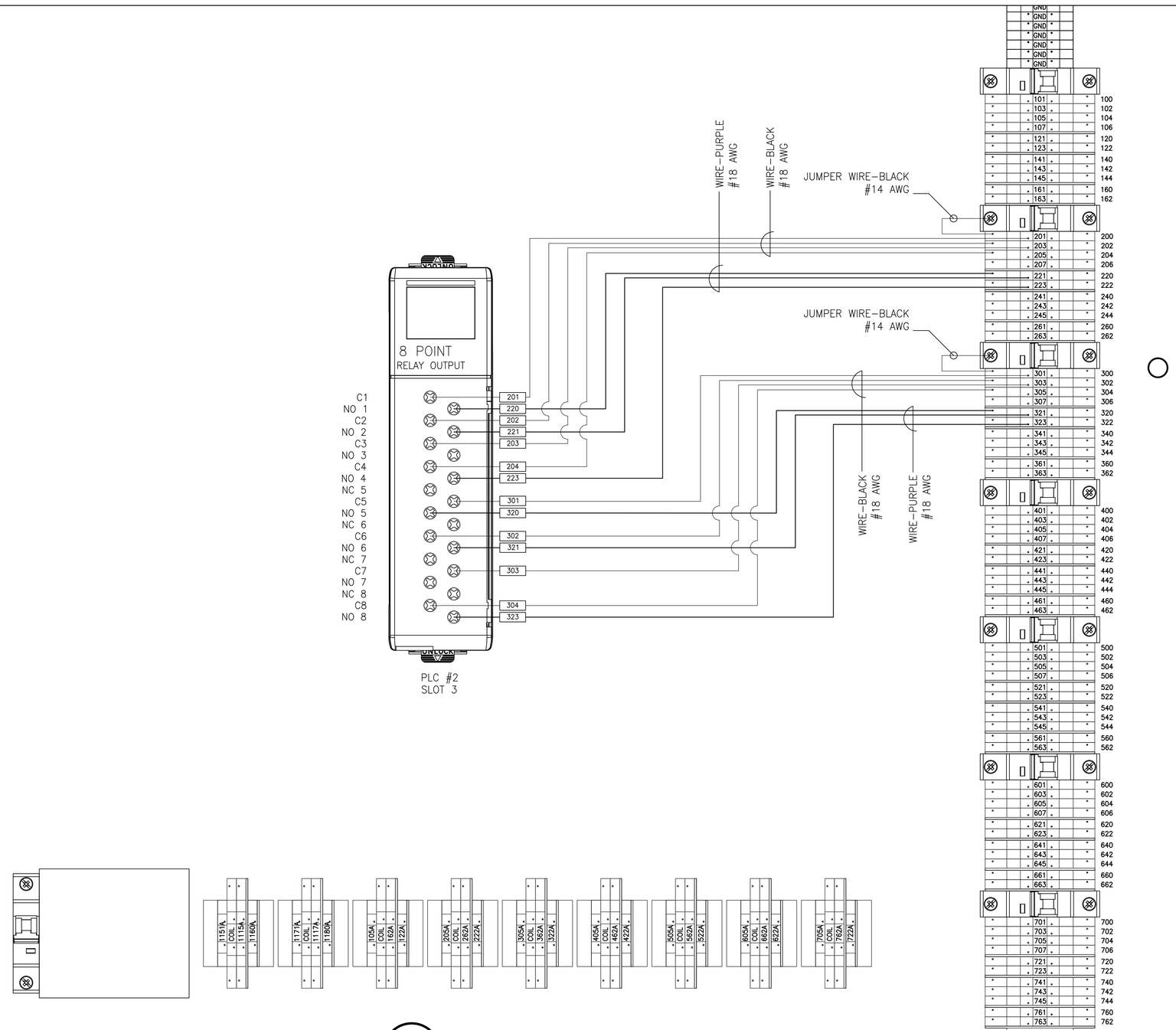
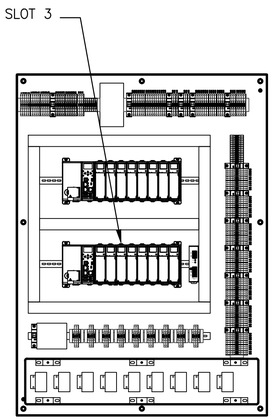


5.3 / 100 PLC #2 SLOT 3 WIRING DIAGRAM

SCALE: NTS

GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.



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CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	25 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
Plotted by: E0111967 Date: Thu, 24 Mar 2016 Time: 04:16:38 pm
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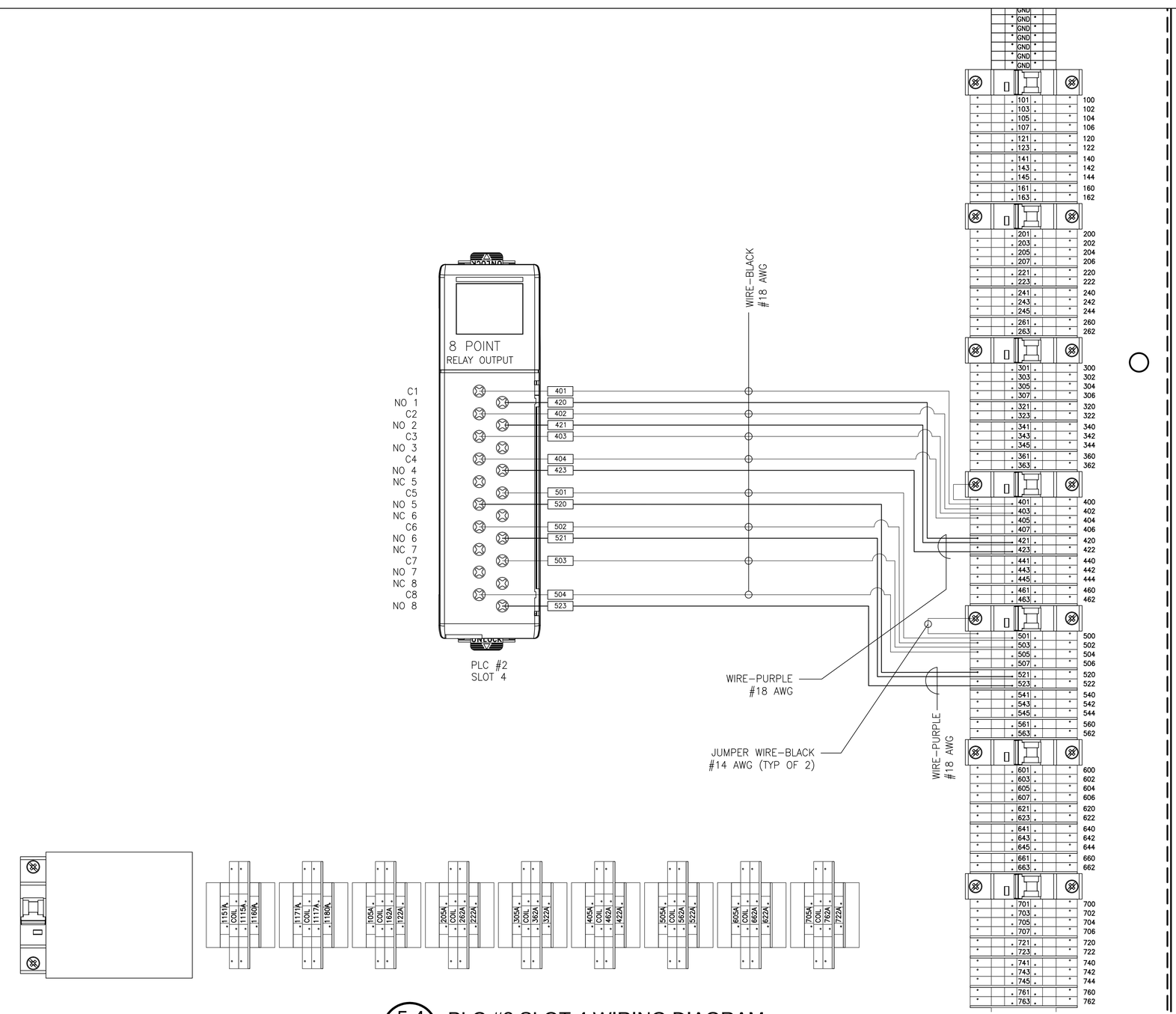
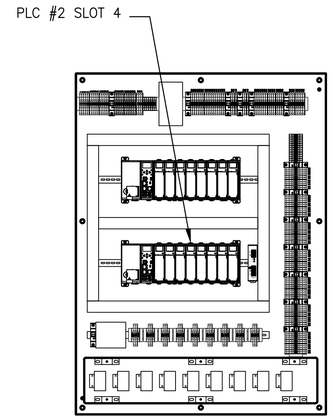


5.4 / 100 PLC #2 SLOT 4 WIRING DIAGRAM

SCALE: NTS

GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.



KEY PLAN

"PROFESSIONAL CERTIFICATION: I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND."

LICENSE No. _____

EXPIRATION DATE: _____

- COMAR 09.23.03.10

DESIGNED	C. Lesefske	9-4-2015 DATE
DRAWN	Y. Liu	9-16-2015 DATE
CHECKED	P. Petersen	9-24-2015 DATE

REFERENCE DRAWINGS

NUMBER	TITLE

REVISIONS

DATE	NUM	DESCRIPTION
1/15/2016	1	100% DESIGN

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DEPARTMENT OF TRANSIT INFRASTRUCTURE AND ENGINEERING SERVICES
CENI - POWER SYSTEMS ENGINEERING

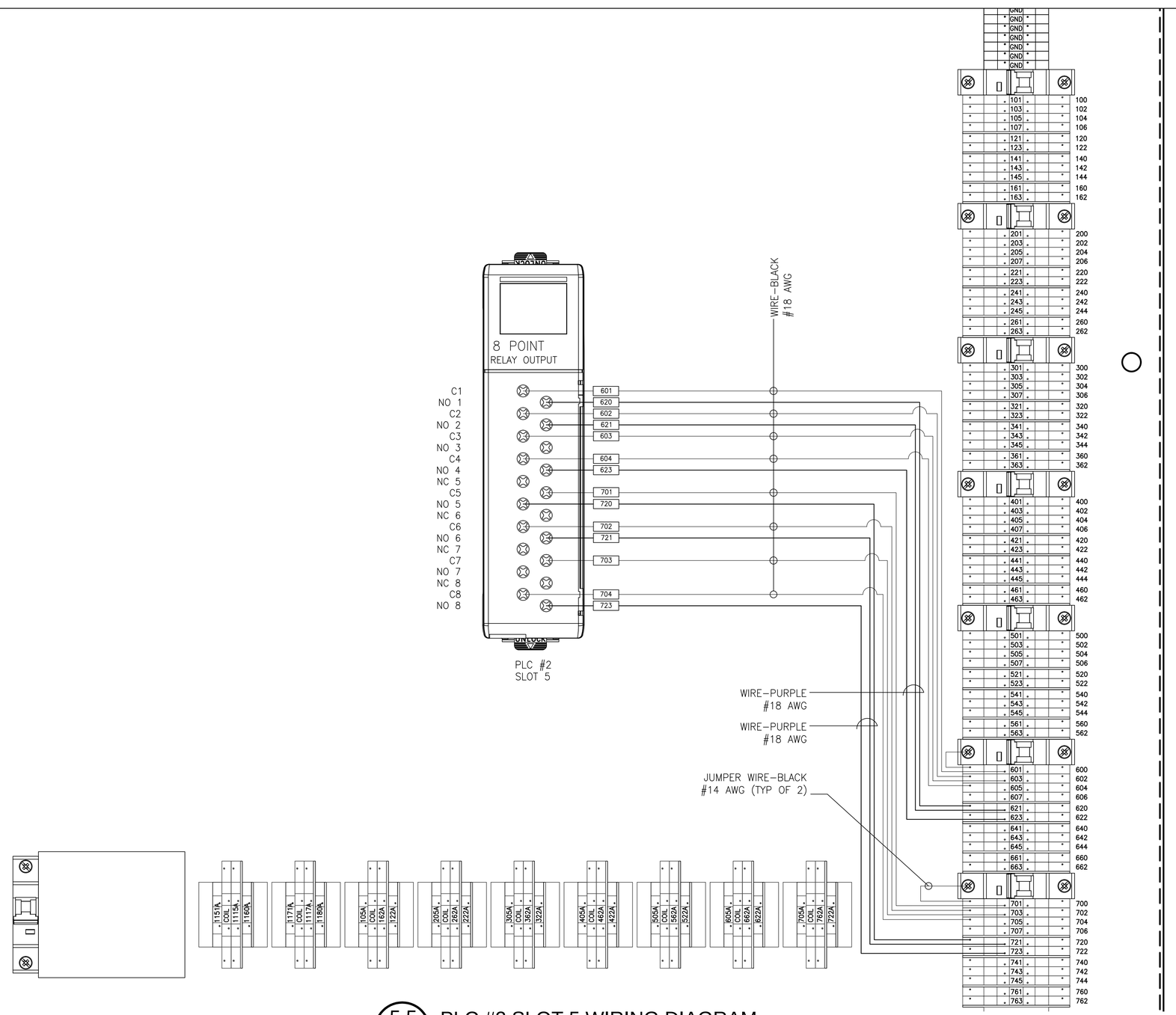
REVISION SUBMITTED _____ DATE

APPROVED _____ DATE
ASHTON ROBINSON
DEPUTY CHIEF ENGINEER

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	26 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
Plotted by: E011967 Date: Thu, 24 Mar 2016 Time: 04:16:43 pm
Xrefs:
Images:

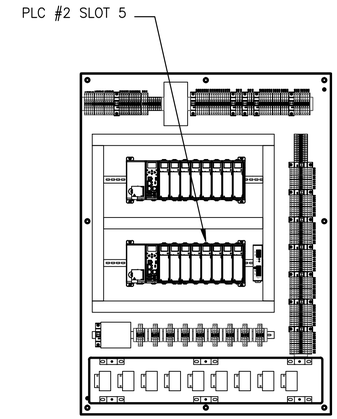


5.5 / 100 PLC #2 SLOT 5 WIRING DIAGRAM

SCALE: NTS

GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.



KEY PLAN

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DEPARTMENT OF TRANSIT INFRASTRUCTURE AND ENGINEERING SERVICES
CENI - POWER SYSTEMS ENGINEERING

REVISION SUBMITTED _____ DATE

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ASHTON ROBINSON
DEPUTY CHIEF ENGINEER

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	27 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
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Xrefs:
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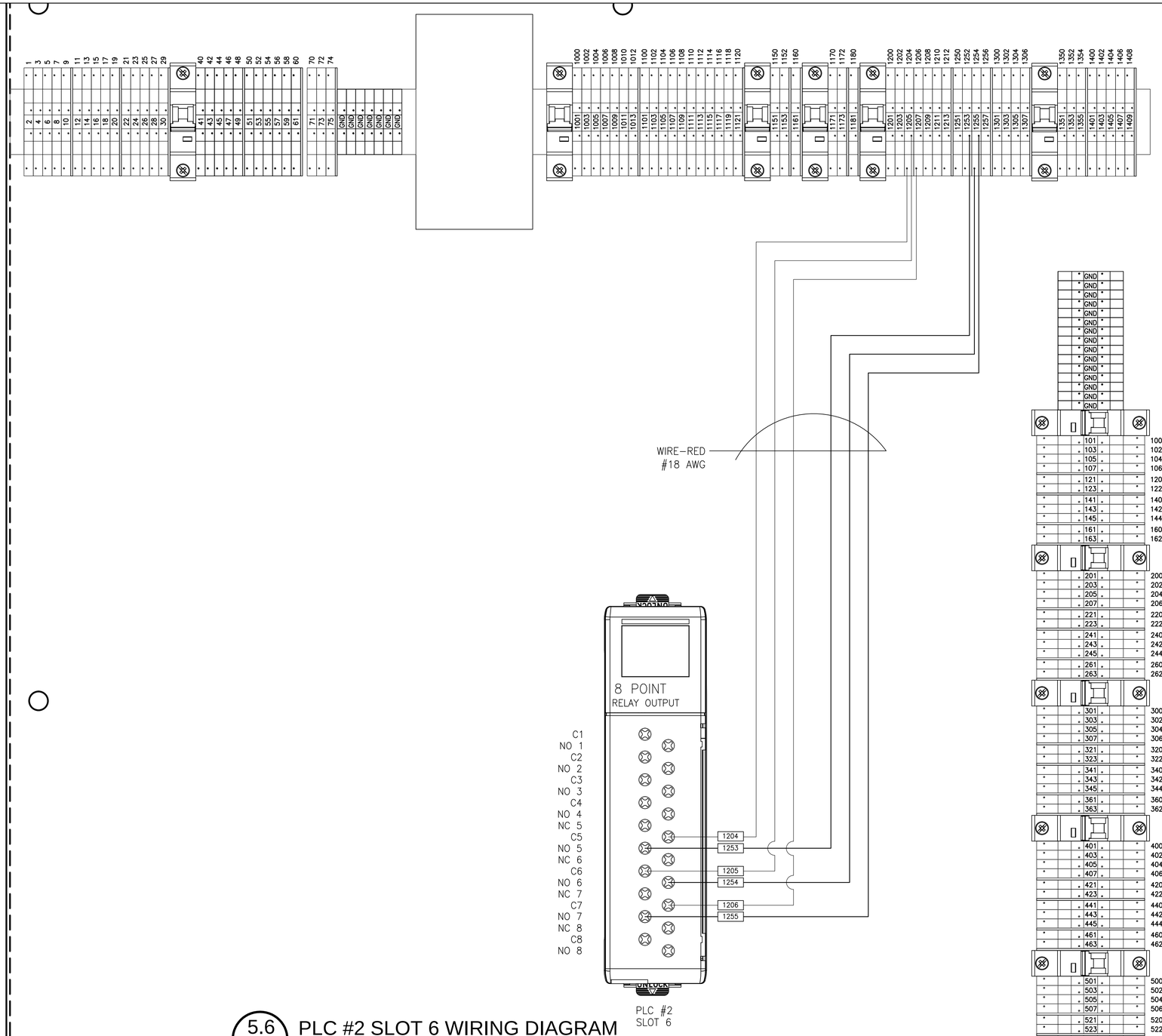
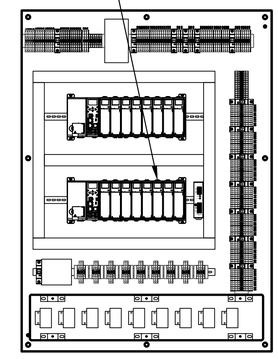


5.6 / 100 PLC #2 SLOT 6 WIRING DIAGRAM

SCALE: NTS

GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.



KEY PLAN

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REFERENCE DRAWINGS	
NUMBER	TITLE

REVISIONS		
DATE	NUM	DESCRIPTION
1/15/2016	1	100% DESIGN

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DEPUTY CHIEF ENGINEER

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	28 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
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Xrefs:
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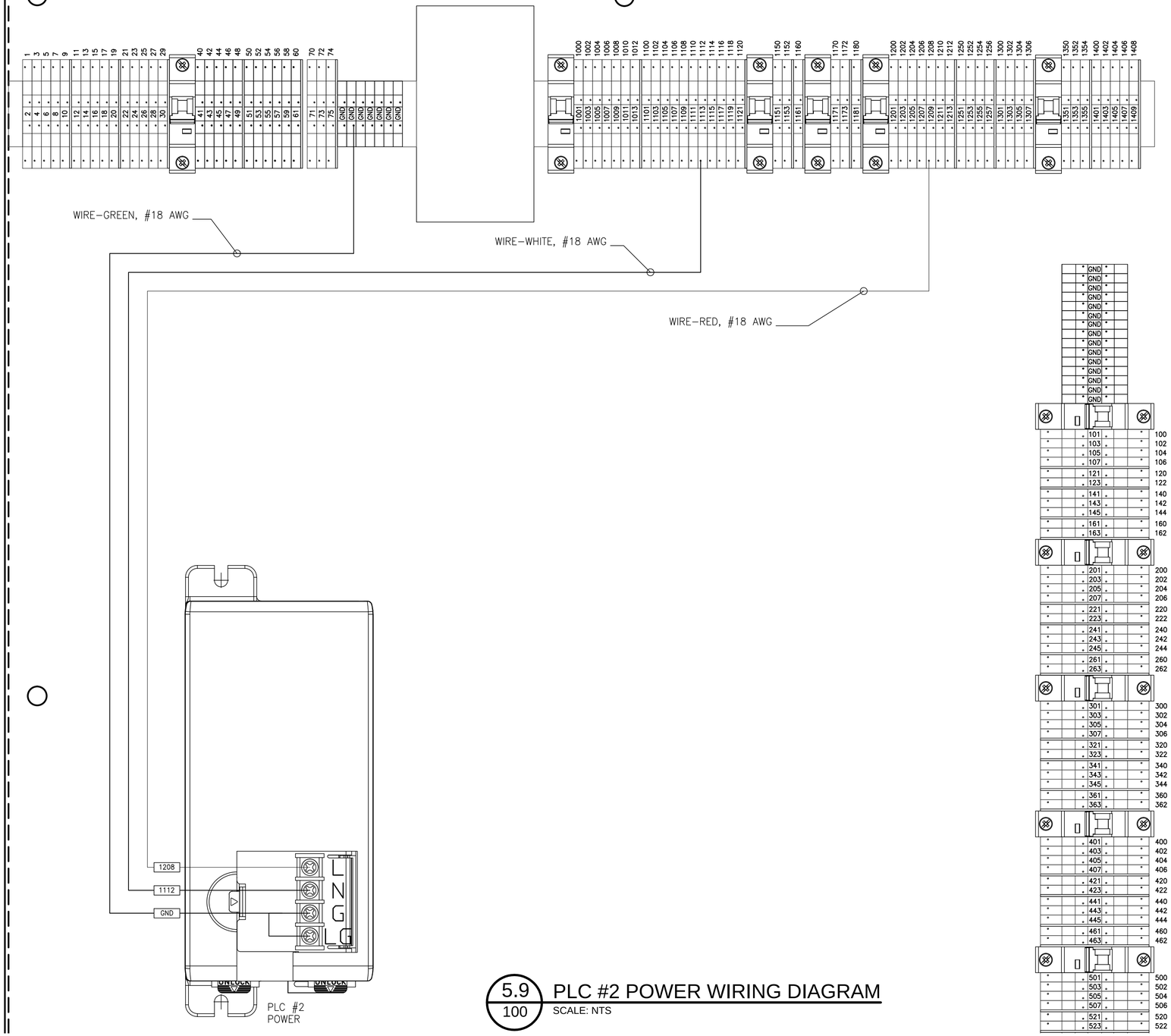


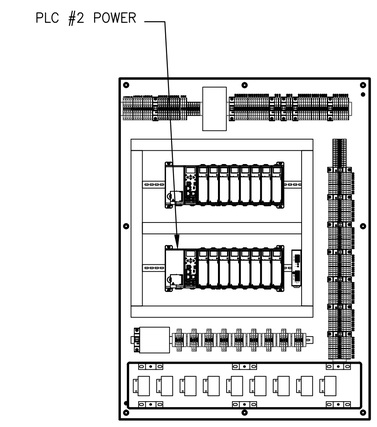
5.9
100

PLC #2 POWER WIRING DIAGRAM

SCALE: NTS

GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.



KEY PLAN

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DEPUTY CHIEF ENGINEER

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	29 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
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Xrefs:
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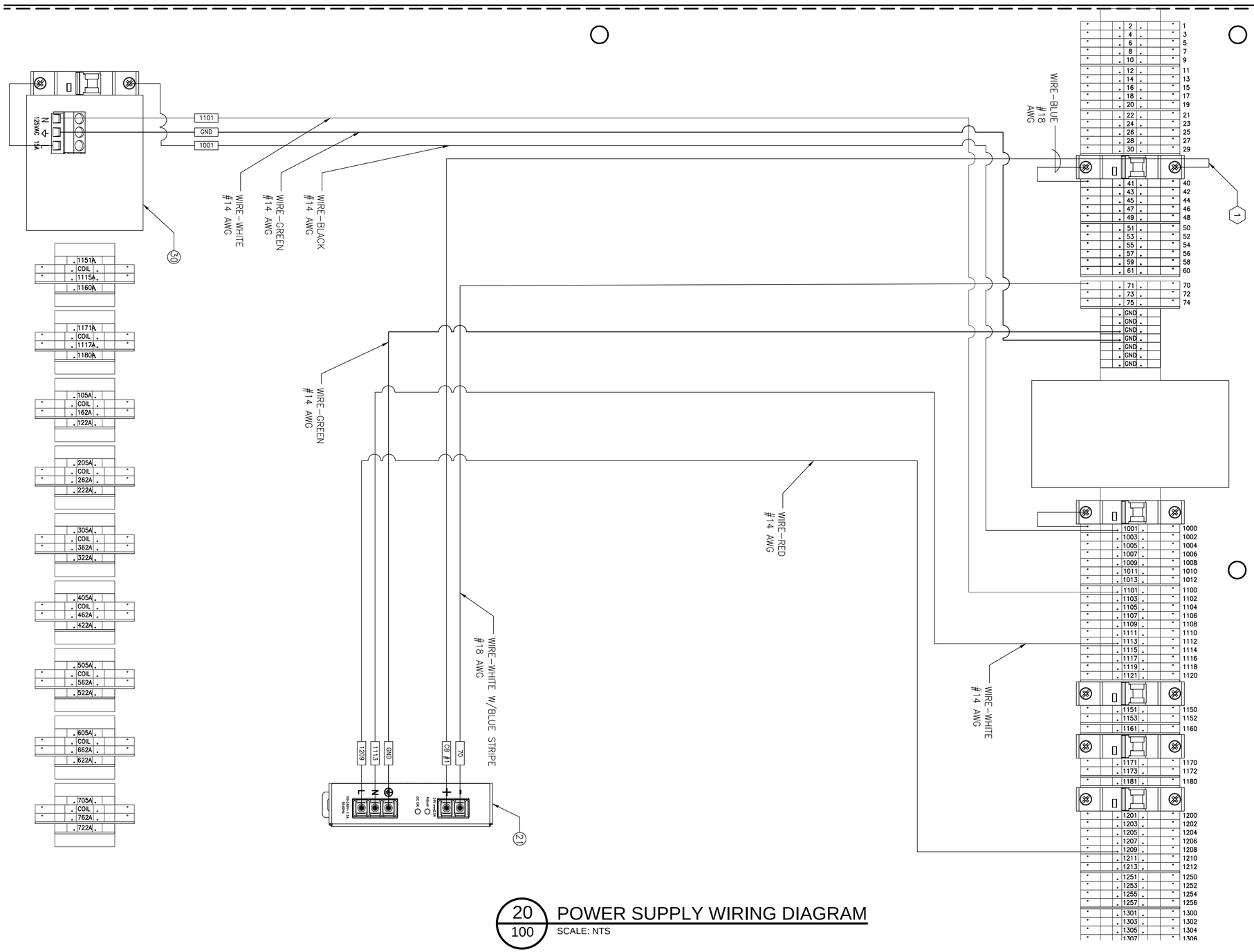


POWER SUPPLY WIRING DIAGRAM

20/100

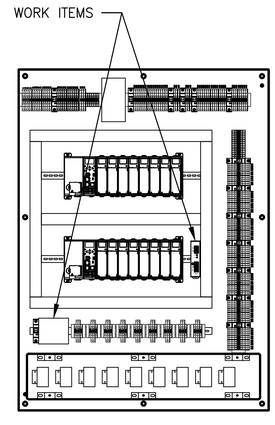
SCALE: NTS

GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.
2. ALL (#) REFER TO ITEMS IN THE CONTROL PANEL EQUIPMENT SCHEDULE ON DRAWING SHEET 2 OR 3.

(#) NOTES:

1. THE +24VDC OUTPUT OF POWER SUPPLY SHALL FEED THE TOP OF CIRCUIT BREAKER CB1 TO PROTECT POWER SUPPLY FROM OVERLOAD.



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REFERENCE DRAWINGS

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WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DEPARTMENT OF TRANSIT INFRASTRUCTURE AND ENGINEERING SERVICES
CENI - POWER SYSTEMS ENGINEERING

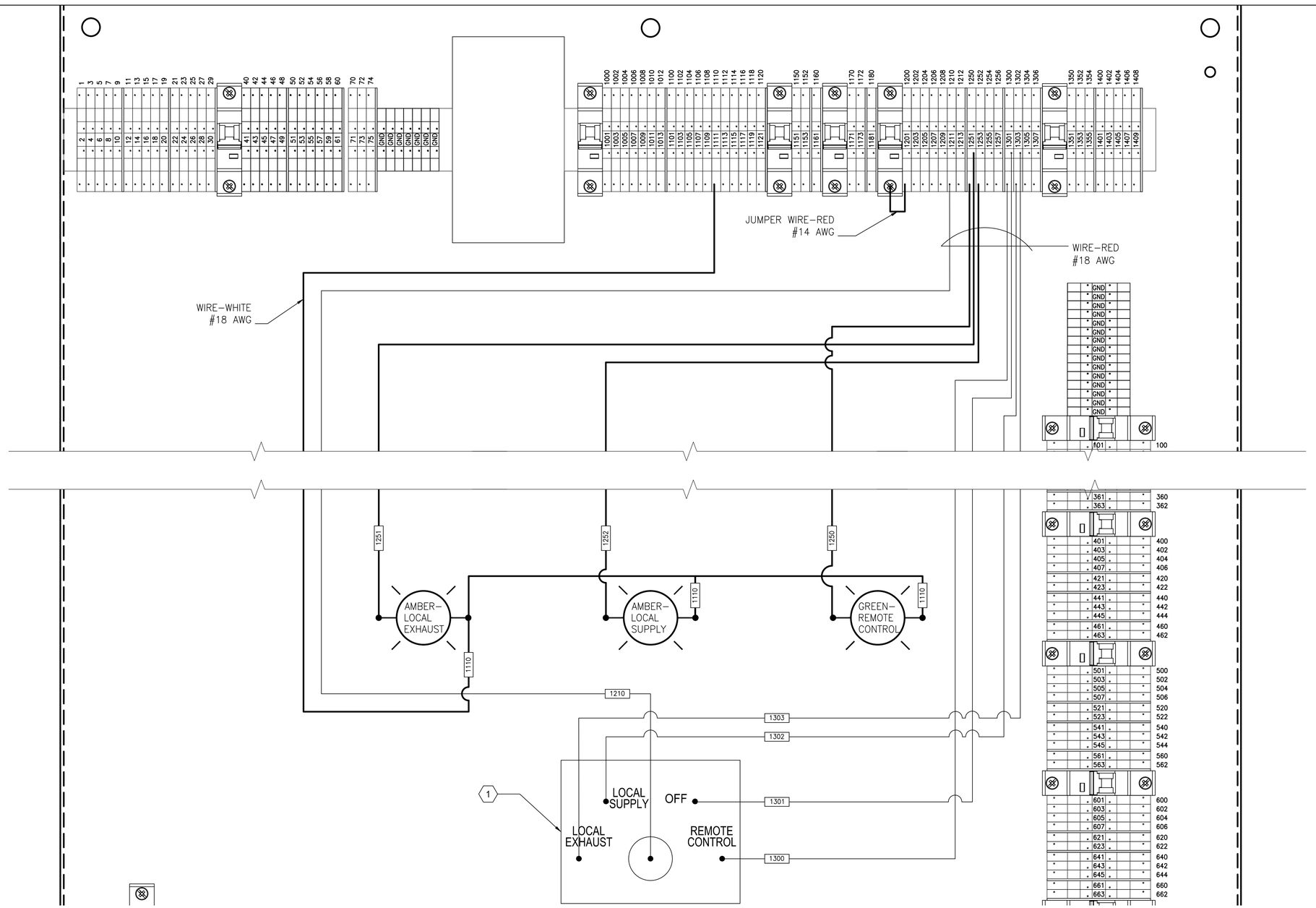
REVISION SUBMITTED _____ DATE

APPROVED _____ DATE
ASHTON ROBINSON
DEPUTY CHIEF ENGINEER

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	30 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
Plotted by: E011967 Date: Thu, 24 Mar 2016 Time: 04:17:04 pm
Xrefs:
Images:

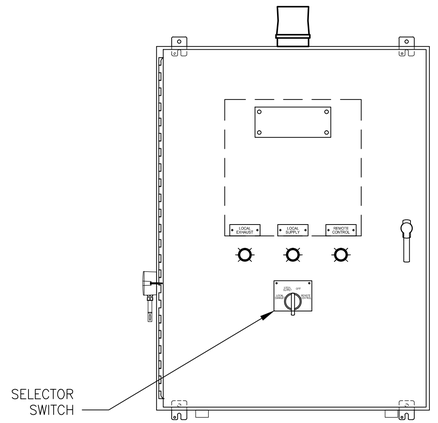


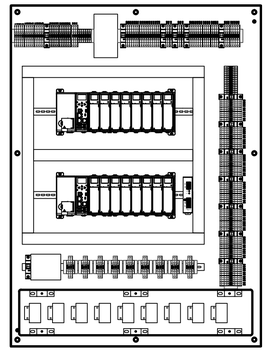
GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.

⟨#⟩ NOTES:

1. SEE NEXT SHEET FOR ADDITIONAL WIRING DETAILS AND SELECTOR SWITCH CONSTRUCTION.





KEY PLAN

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- COMAR 09.23.03.10

21/100 CONTROL SWITCH WIRING DIAGRAM

SCALE: NTS

DESIGNED	C. Lesefske	9-4-2015 DATE
DRAWN	Y. Liu	9-16-2015 DATE
CHECKED	P. Petersen	9-24-2015 DATE

REFERENCE DRAWINGS

NUMBER	TITLE

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DATE	NUM	DESCRIPTION
1/15/2016	1	100% DESIGN

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DEPARTMENT OF TRANSIT INFRASTRUCTURE AND ENGINEERING SERVICES
CENI - POWER SYSTEMS ENGINEERING

REVISION SUBMITTED _____ DATE

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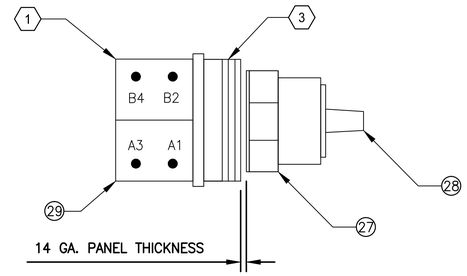
ASHTON ROBINSON
DEPUTY CHIEF ENGINEER

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	31 of 42

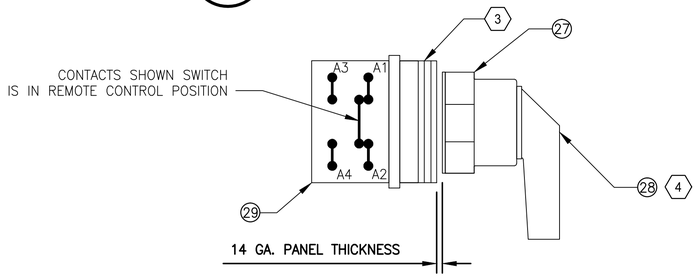
Drawing File: N:\ROBINSON-ELECT-MECH\MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
Plotted by: E01967 Date: Thu, 24 Mar 2016 Time: 04:17:06 pm
Xrefs:
Images:

SELECTOR SWITCH TRUTH TABLE				
	LOCAL EXHAUST	LOCAL SUPPLY	OFF	REMOTE CONTROL
A1				●
A2				●
A3		●		
A4		●		
B1	●			
B2	●			
B3			●	
B4			●	



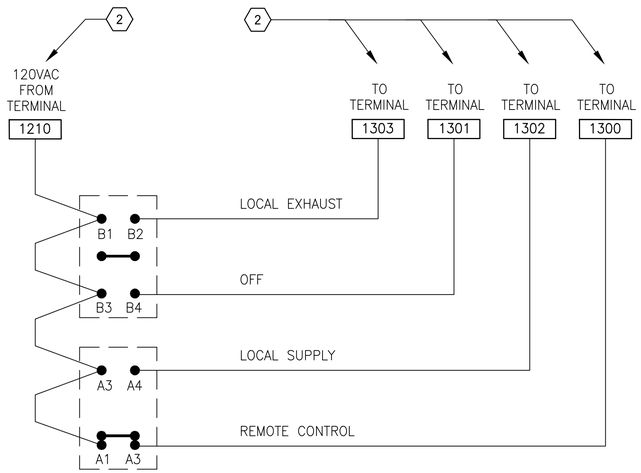
27/100 TOP VIEW OF SELECTOR SWITCH

SCALE: N.T.S.



28/100 SIDE VIEW OF SELECTOR SWITCH

SCALE: N.T.S.



29/100 SELECTOR SWITCH WIRING SCHEMATIC

SCALE: N.T.S.

GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.
2. ALL (#) REFER TO ITEMS IN THE CONTROL PANEL EQUIPMENT SCHEDULE ON DRAWING SHEET 2 OR 3.

(#) NOTES:

1. THE FOUR POSITION SELECTOR SWITCH SHALL HAVE A DEDICATED DRY TYPE CONTACT OUTPUT FOR EACH OF THE DEPICTED POSITIONS. A COMMON 120VAC POWER WIRE SHALL PROVIDE POWER TO EACH OF THE INDIVIDUAL CONTACTS.
2. SEE PREVIOUS SHEET FOR ADDITIONAL INFORMATION ON WIRE CONTINUATIONS.
3. REFER TO THE MANUFACTURERS RECOMMENDATIONS FOR RUBBER SEALING WASHERS ON THE SELECTOR SWITCH. THE SWITCH WILL BE SUBJECT TO HOSE DOWN WATER CONTACT.
4. THE SELECTOR SWITCH SHALL RECEIVE AN ORANGE OVERSIZED SWITCH OPERATOR HANDLE FOR USE BY GLOVED HANDS DURING FIRE EMERGENCY.

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REFERENCE DRAWINGS

NUMBER	TITLE

REVISIONS

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WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DEPARTMENT OF TRANSIT INFRASTRUCTURE AND ENGINEERING SERVICES
CENI - POWER SYSTEMS ENGINEERING

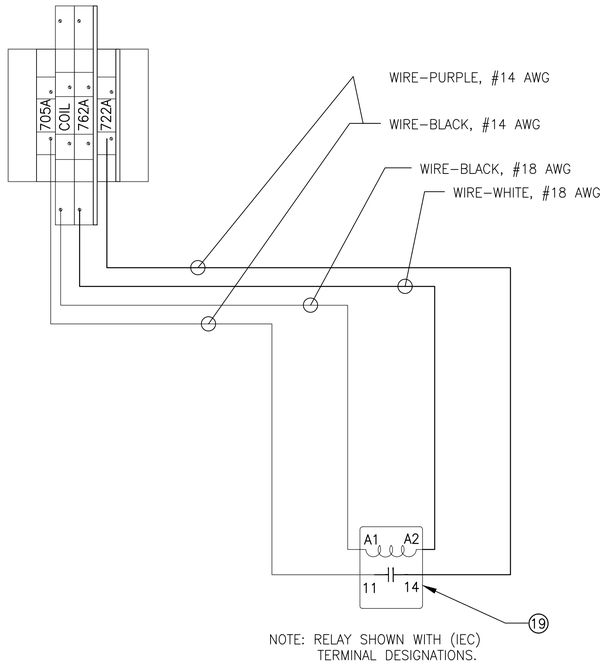
_____ DATE

APPROVED
ASHTON ROBINSON DATE
DEPUTY CHIEF ENGINEER

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	32 of 42

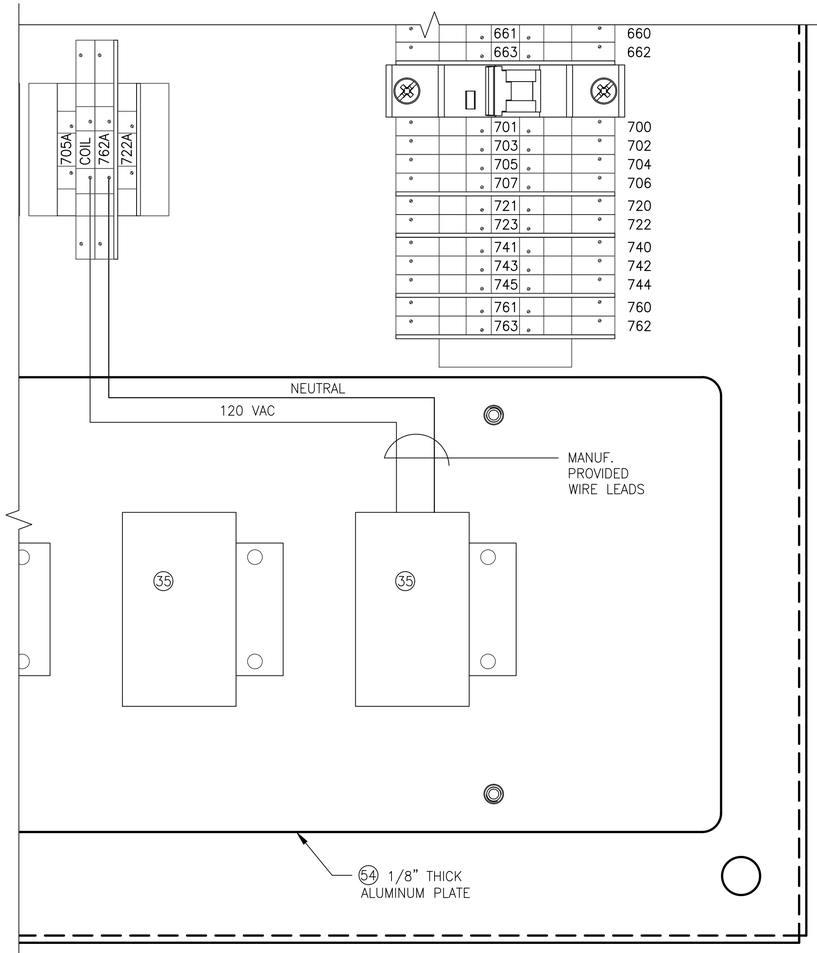
Drawing File: N:\ROBINSON-ELECT-MECH\MECH\PLC PANEL LAYOUT\CAD\ST-ME-FAN-100 SELECTOR SWITCH DETAILS.DWG
Plotted by: E0111967 Date: Thu, 24 Mar 2016 Time: 04:17:10 pm
Xrefs:
Images:



NOTE: RELAY SHOWN WITH (IEC) TERMINAL DESIGNATIONS.

30/100 TYP. RELAY WIRING DIAGRAM

SCALE: NTS

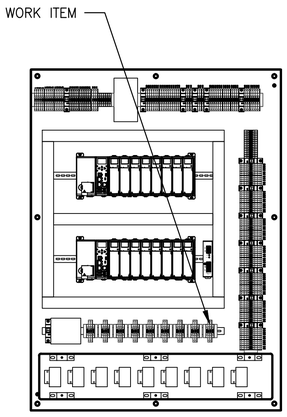


31/100 TYP. SOLENOID VALVE WIRING DIAGRAM

SCALE: NTS

GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.
2. ALL (#) REFER TO ITEMS IN THE CONTROL PANEL EQUIPMENT SCHEDULE ON DRAWING SHEET 2 OR 3.
3. EACH SET OF FOUR TERMINALS FOR THE DAMPERS CONTROL THE AIR VALVES AND RELAYS. THE CENTER TWO DOUBLE LEVEL TERMINALS PROVIDE THE COIL POWER FOR THE AIR VALVES AND RELAYS, WHILE THE OUTER TWO SINGLE LEVEL TERMINALS ARE THE HIGHER CURRENT PATH FOR RELAYS ONLY.



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REVISION SUBMITTED _____ DATE

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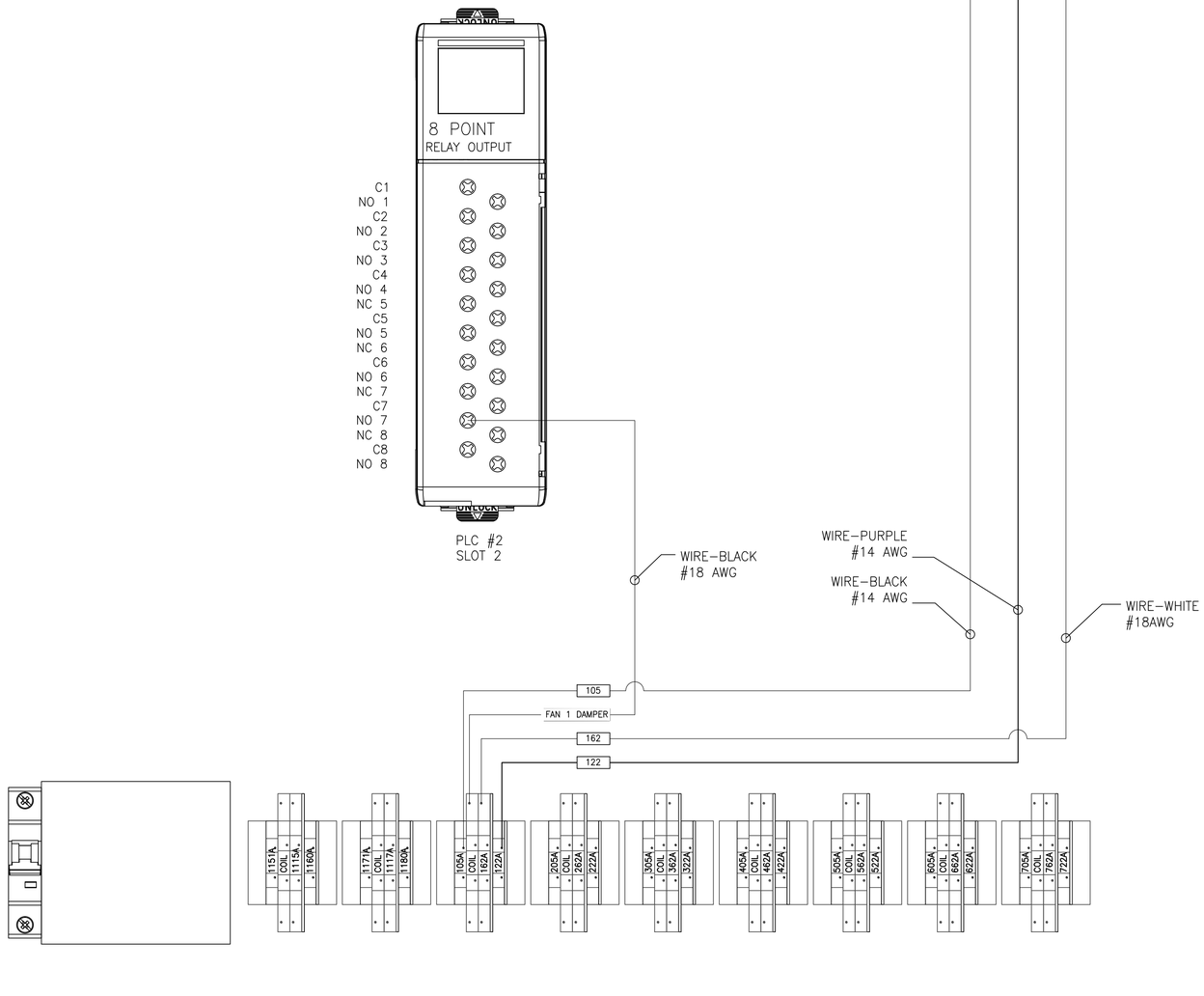
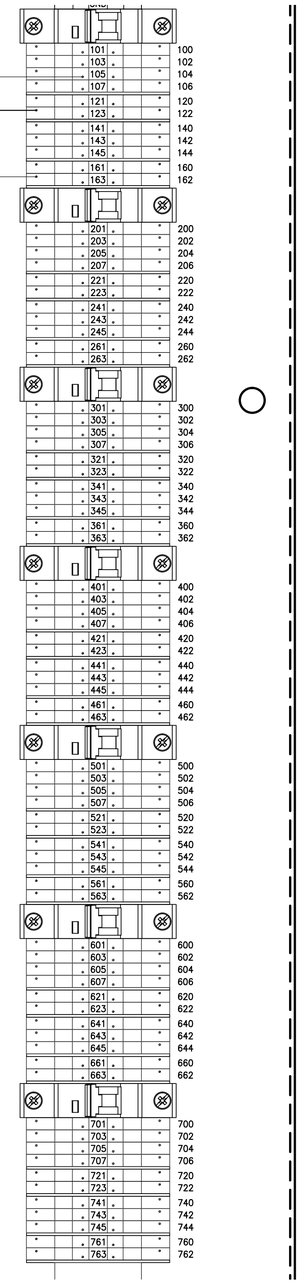
ASHTON ROBINSON
DEPUTY CHIEF ENGINEER

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	33 of 42

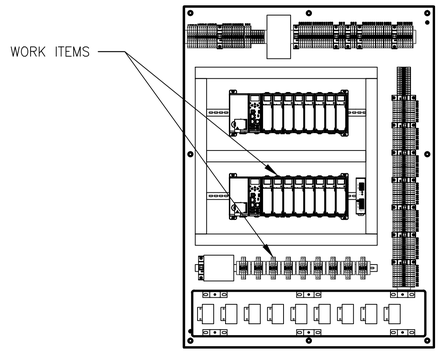
Drawing File: N:\ROBINSON-ELECT-MECH\MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
Plotted by: E011967 Date: Thu, 24 Mar 2016 Time: 04:17:26 pm
Xrefs:
Images:





GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.



KEY PLAN

11.1 / 100 PNEUMATIC CONTROL WIRING DIAGRAM

SCALE: NTS

"PROFESSIONAL CERTIFICATION: I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND."

LICENSE No. _____

EXPIRATION DATE: _____

- COMAR 09.23.03.10

DESIGNED	C. Lesefske	9-4-2015 DATE
DRAWN	Y. Liu	9-16-2015 DATE
CHECKED	P. Petersen	9-24-2015 DATE

REFERENCE DRAWINGS

NUMBER	TITLE

REVISIONS

DATE	NUM	DESCRIPTION
1/15/2016	1	100% DESIGN

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DEPARTMENT OF TRANSIT INFRASTRUCTURE AND ENGINEERING SERVICES
CENI - POWER SYSTEMS ENGINEERING

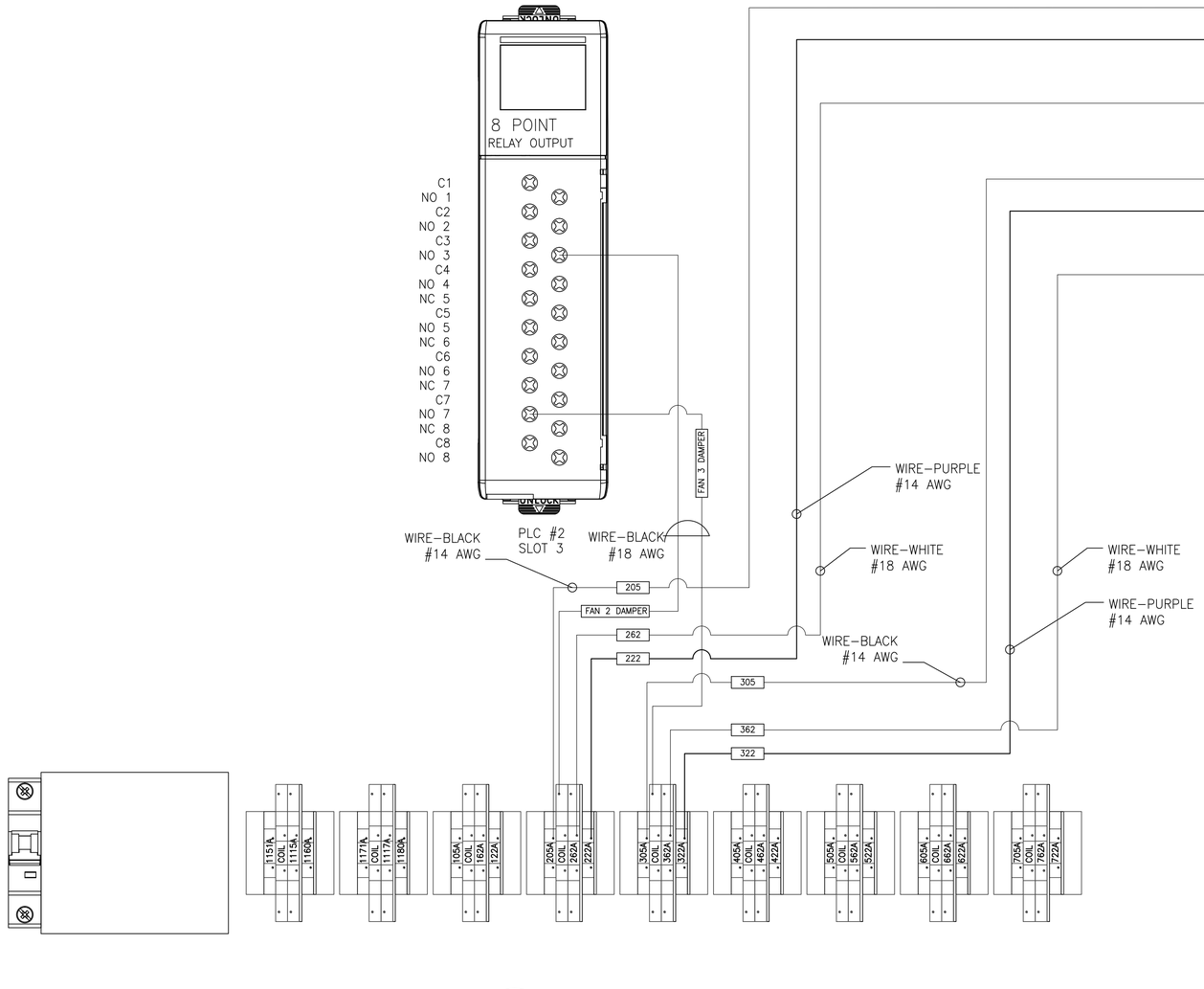
REVISION SUBMITTED _____ DATE

APPROVED _____ DATE
ASHTON ROBINSON
DEPUTY CHIEF ENGINEER

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

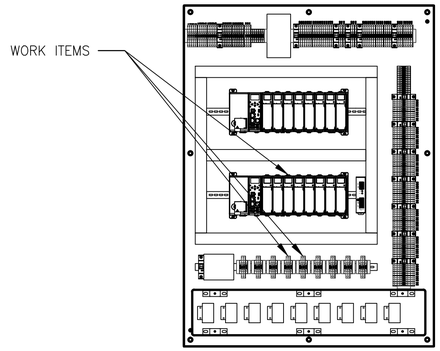
CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	34 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
Plotted by: E0111967 Date: Thu, 24 Mar 2016 Time: 04:17:32 pm
Xrefs:
Images:



GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.



KEY PLAN

11.2 / 100 PNEUMATIC CONTROL WIRING DIAGRAM

SCALE: NTS

"PROFESSIONAL CERTIFICATION: I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND."

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EXPIRATION DATE: _____

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DRAWN	Y. Liu	9-16-2015 DATE
CHECKED	P. Petersen	9-24-2015 DATE

REFERENCE DRAWINGS

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REVISIONS

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WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DEPARTMENT OF TRANSIT INFRASTRUCTURE AND ENGINEERING SERVICES
CENI - POWER SYSTEMS ENGINEERING

REVISION SUBMITTED _____ DATE

APPROVED _____ DATE
ASHTON ROBINSON
DEPUTY CHIEF ENGINEER

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	35 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
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Xrefs:
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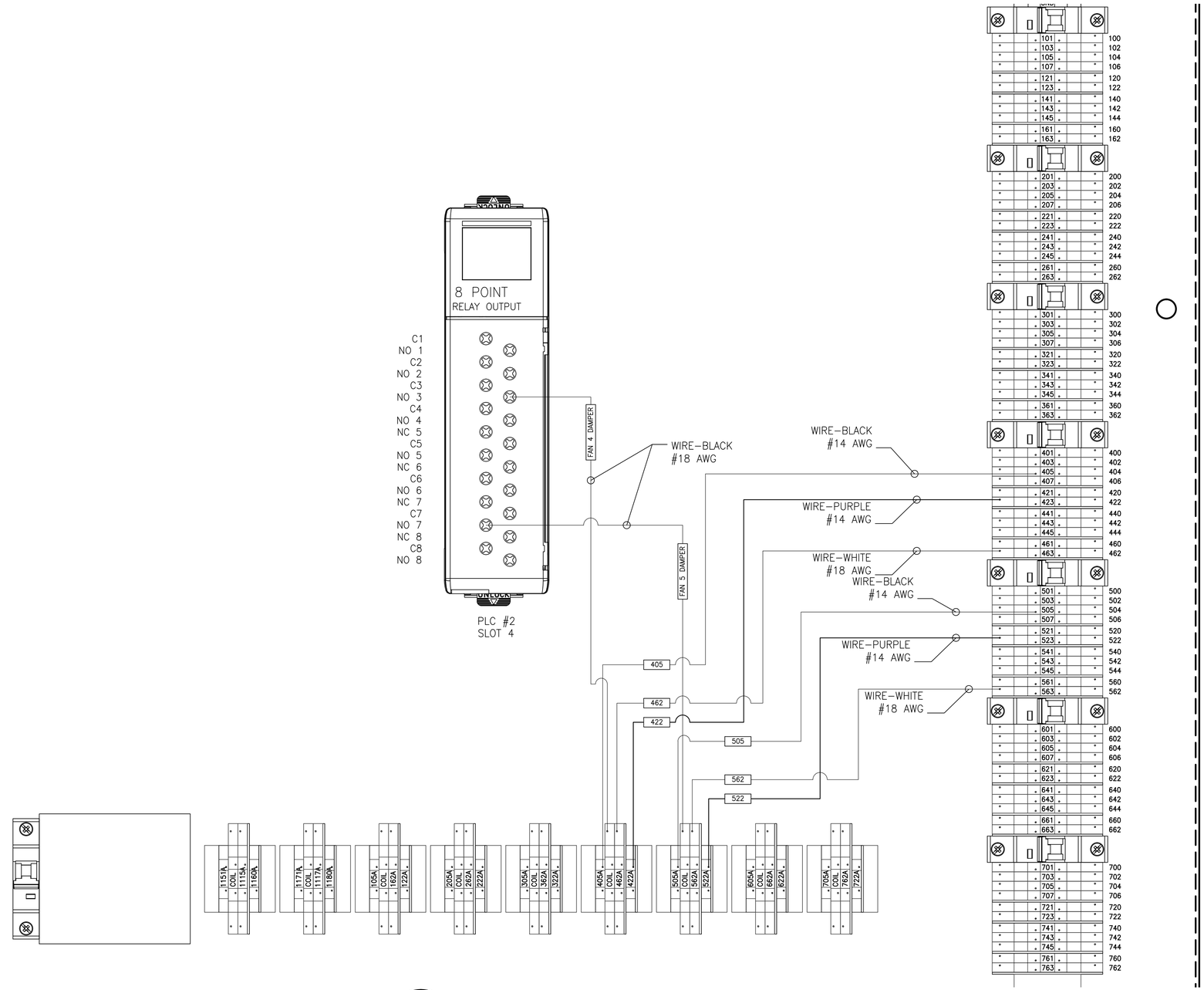
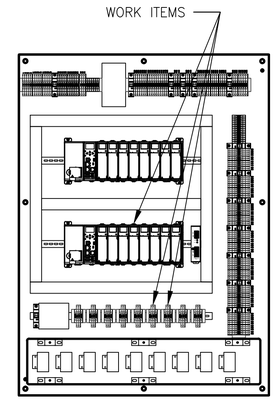


11.4 / 100 PNEUMATIC CONTROL WIRING DIAGRAM

SCALE: NTS

GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.



KEY PLAN

"PROFESSIONAL CERTIFICATION: I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND."

LICENSE No. _____

EXPIRATION DATE: _____

- COMAR 09.23.03.10

DESIGNED	C. Lesefske	9-4-2015 DATE
DRAWN	Y. Liu	9-16-2015 DATE
CHECKED	P. Petersen	9-24-2015 DATE

REFERENCE DRAWINGS

NUMBER	TITLE

REVISIONS

DATE	NUM	DESCRIPTION
1/15/2016	1	100% DESIGN

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DEPARTMENT OF TRANSIT INFRASTRUCTURE AND ENGINEERING SERVICES
CENI - POWER SYSTEMS ENGINEERING

REVISION SUBMITTED _____ DATE

APPROVED _____ DATE
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DEPUTY CHIEF ENGINEER

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	36 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
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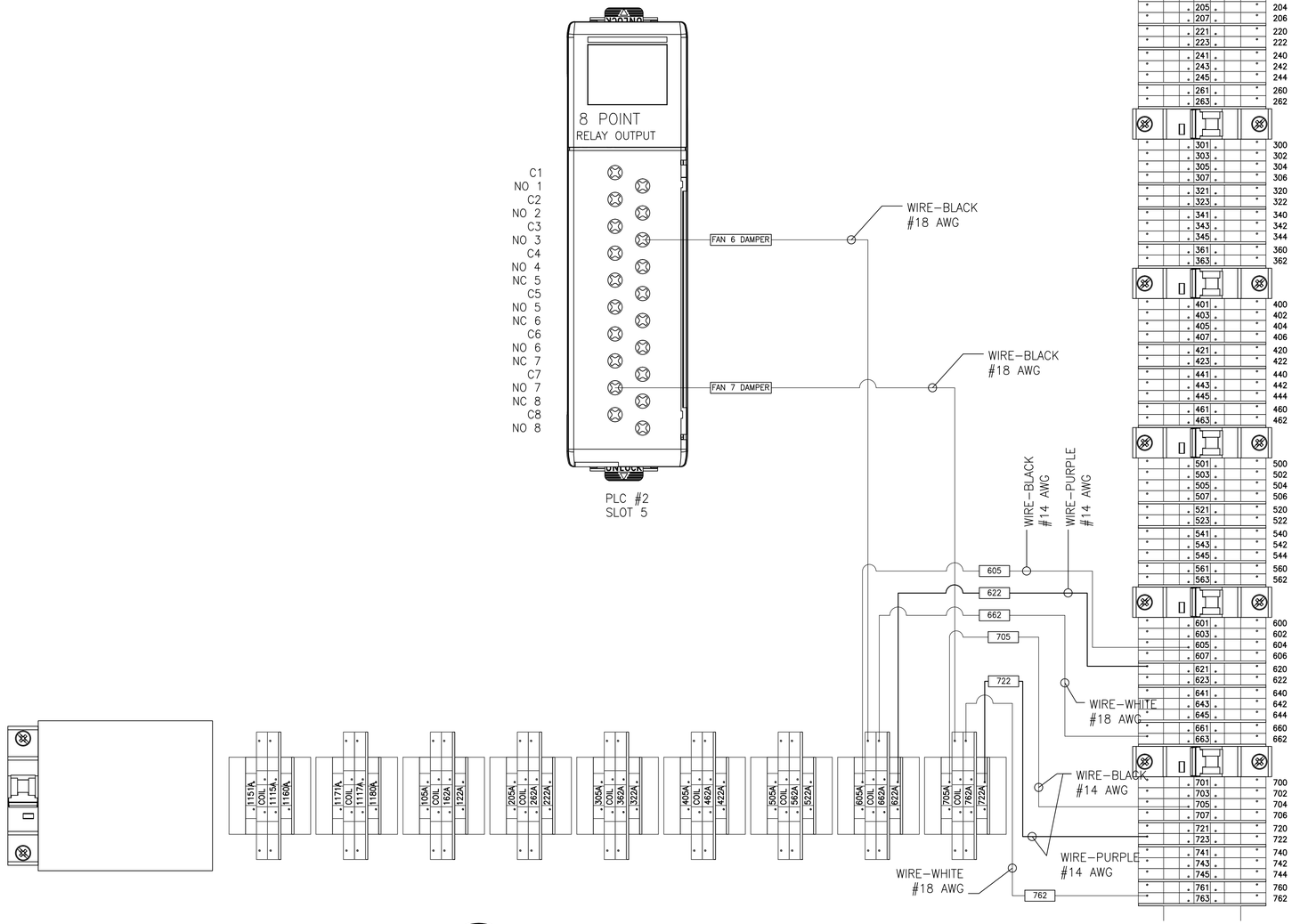
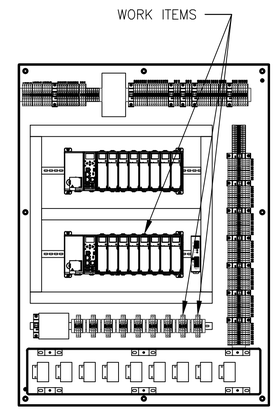


GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.



KEY PLAN

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LICENSE No. _____

EXPIRATION DATE: _____

- COMAR 09.23.03.10

11.6 / 100

PNEUMATIC CONTROL WIRING DIAGRAM

SCALE: NTS

DESIGNED	C. Lesefske	9-4-2015 DATE
DRAWN	Y. Liu	9-16-2015 DATE
CHECKED	P. Petersen	9-24-2015 DATE

REFERENCE DRAWINGS

NUMBER	TITLE

REVISIONS

DATE	NUM	DESCRIPTION
1/15/2016	1	100% DESIGN

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DEPARTMENT OF TRANSIT INFRASTRUCTURE AND ENGINEERING SERVICES
CENI - POWER SYSTEMS ENGINEERING

REVISION SUBMITTED _____ DATE

APPROVED _____ DATE
ASHTON ROBINSON
DEPUTY CHIEF ENGINEER

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	37 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
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Date: Thu, 24 Mar 2016 Time: 04:17:48 pm
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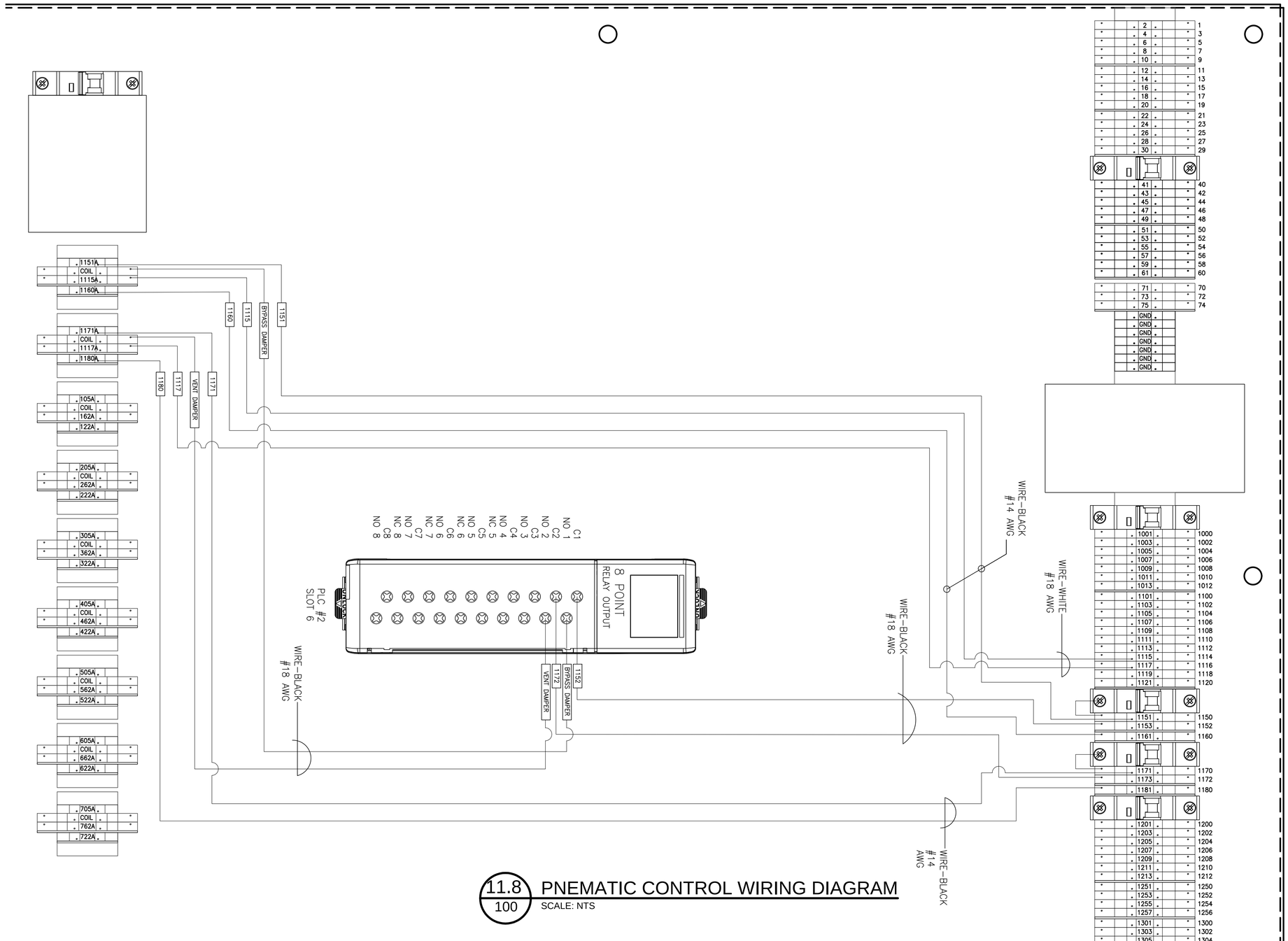


11.8
100

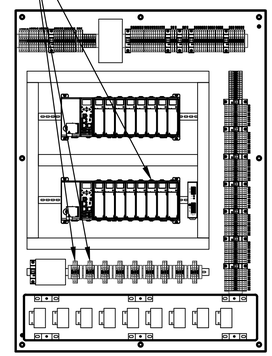
PNEMATIC CONTROL WIRING DIAGRAM

SCALE: NTS

GENERAL NOTES:

1. INTERNAL PANEL WIRING SHALL BE EQUIPPED WITH MACHINE PRINTED HEAT SHRINK LABELS AT EACH TERMINATION POINT. TEXT SIZE SHALL BE 1/8 INCH TALL. THE LABEL SHALL BE AFFIXED AS CLOSE TO THE POINT OF TERMINATION AS POSSIBLE AND BE VISIBLE. ALL WIRES SHALL HAVE LABELS AT EACH END OF WIRE AS IDENTIFIED ON THE WIRING DIAGRAM.

WORK ITEMS



KEY PLAN

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NUMBER	TITLE

REVISIONS		
DATE	NUM	DESCRIPTION
1/15/2016	1	100% DESIGN

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

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TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	38 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\PLC PANEL LAYOUT\CAD\FAN PLC PANEL.DWG
Plotted by: E011967 Date: Thu, 24 Mar 2016 Time: 04:17:54 pm
Xrefs:
Images:

	PLC 1 SLOT 1	PLC 1 SLOT 2	PLC 1 SLOT 3	PLC 1 SLOT 4	PLC 1 SLOT 5	PLC 1 SLOT 6	PLC 1 SLOT 7	PLC 1 SLOT 8
POINT #1	SELECTOR SWITCH- "REMOTE CONTROL" POSITION	FAN #2 CONTROL POWER FROM MOTOR STARTER	FAN #4 CONTROL POWER FROM MOTOR STARTER	FAN #6 CONTROL POWER FROM MOTOR STARTER	BYPASS DAMPER LIMIT SWITCH #1	DTS COMMAND: "AUTOMATIC OPERATION"	FAN #1 CURRENT TRANSDUCER	CONTROL AIR PRESSURE-NON REGULATED
POINT #2	SELECTOR SWITCH- "OFF" POSITION	FAN #2 FLOW SWITCH-EXHAUST DIRECTION	FAN #4 FLOW SWITCH-EXHAUST DIRECTION	FAN #6 FLOW SWITCH-EXHAUST DIRECTION	BYPASS DAMPER LIMIT SWITCH #2	DTS COMMAND: "EMERGENCY ON"	FAN #2 CURRENT TRANSDUCER	CONTROL AIR PRESSURE-REGULATED
POINT #3	SELECTOR SWITCH- "LOCAL SUPPLY" POSITION	FAN #2 FLOW SWITCH-SUPPLY DIRECTION	FAN #4 FLOW SWITCH-SUPPLY DIRECTION	FAN #6 FLOW SWITCH-SUPPLY DIRECTION	VENT SHAFT DAMPER STATUS (FUTURE)	DTS COMMAND: "EMERGENCY OFF"	FAN #3 CURRENT TRANSDUCER	
POINT #4	SELECTOR SWITCH- "LOCAL EXHAUST" POSITION	FAN #2 DAMPER LIMIT SWITCH	FAN #4 DAMPER LIMIT SWITCH	FAN #6 DAMPER LIMIT SWITCH	VENT SHAFT DAMPER STATUS (FUTURE)	DTS COMMAND: "SUPPLY"	FAN #4 CURRENT TRANSDUCER	
POINT #5	SPARE	FAN #2 SPARE	FAN #4 SPARE	FAN #6 SPARE	AVR STATUS- NORMAL (FUTURE)	DTS COMMAND: "EXHAUST"	FAN #5 CURRENT TRANSDUCER	TEMPERATURE TRANSMITTER- TRACK SIDE
POINT #6	SPARE	FAN #2 SPARE	FAN #4 SPARE	FAN #6 SPARE	AVR STATUS- ABNORMAL (FUTURE)	DTS INDICATION COMMON POWER PROOF	FAN #6 CURRENT TRANSDUCER	TEMPERATURE TRANSMITTER- FAN GALLERY LEVEL
POINT #7		FAN #2 SPARE	FAN #4 SPARE	FAN #6 SPARE	AVR- ALARM SWITCH: IN SILENCE MODE (FUTURE)	DTS ABNORMAL COMMON POWER PROOF	FAN #7 CURRENT TRANSDUCER	SPARE
POINT #8					SPARE			
POINT #9	FAN #1 CONTROL POWER FROM MOTOR STARTER	FAN #3 CONTROL POWER FROM MOTOR STARTER	FAN #5 CONTROL POWER FROM MOTOR STARTER	FAN #7 CONTROL POWER FROM MOTOR STARTER	CONTROL POWER LINE FILTER STATUS- NORMAL			
POINT #10	FAN #1 FLOW SWITCH-EXHAUST DIRECTION	FAN #3 FLOW SWITCH-EXHAUST DIRECTION	FAN #5 FLOW SWITCH-EXHAUST DIRECTION	FAN #7 FLOW SWITCH-EXHAUST DIRECTION	CONTROL POWER LINE FILTER STATUS-ABNORMAL			
POINT #11	FAN #1 FLOW SWITCH-SUPPLY DIRECTION	FAN #3 FLOW SWITCH-SUPPLY DIRECTION	FAN #5 FLOW SWITCH-SUPPLY DIRECTION	FAN #7 FLOW SWITCH-SUPPLY DIRECTION				
POINT #12	FAN #1 DAMPER LIMIT SWITCH	FAN #3 DAMPER LIMIT SWITCH	FAN #5 DAMPER LIMIT SWITCH	FAN #7 DAMPER LIMIT SWITCH				
POINT #13	FAN #1 SPARE	FAN #3 SPARE	FAN #5 SPARE	FAN #7 SPARE				
POINT #14	FAN #1 SPARE	FAN #3 SPARE	FAN #5 SPARE	FAN #7 SPARE				
POINT #15	FAN #1 SPARE	FAN #3 SPARE	FAN #5 SPARE	FAN #7 SPARE				
POINT #16								

	PLC 2 SLOT 1	PLC 2 SLOT 2	PLC 2 SLOT 3	PLC 2 SLOT 4	PLC 2 SLOT 5	PLC 2 SLOT 6	PLC 2 SLOT 7	PLC 2 SLOT 8
POINT #1	DTS INDICATION: "AUTOMATIC OPERATION"	INDICATOR LIGHT- REMOTE STATUS	FAN #2 MOTOR STARTER COIL- SUPPLY	FAN #4 MOTOR STARTER COIL- SUPPLY	FAN #6 MOTOR STARTER COIL- SUPPLY	BYPASS DAMPER AIR VALVE/RELAY		
POINT #2	DTS INDICATION: "EMERGENCY ON"	INDICATOR LIGHT- LOCAL EXHAUST	FAN #2 MOTOR STARTER COIL- EXHAUST	FAN #4 MOTOR STARTER COIL- EXHAUST	FAN #6 MOTOR STARTER COIL- EXHAUST	VENT SHAFT #1 DAMPER AIR VALVE/RELAY		
POINT #3	DTS INDICATION: "EMERGENCY OFF"	INDICATOR LIGHT- LOCAL SUPPLY	FAN #2 DISCHARGE AIR DAMPER AIR VALVE/RELAY	FAN #4 DISCHARGE AIR DAMPER AIR VALVE/RELAY	FAN #6 DISCHARGE AIR DAMPER AIR VALVE/RELAY	VENT SHAFT #2 DAMPER AIR VALVE/RELAY (FUTURE)		
POINT #4	DTS INDICATION: "SUPPLY"		FAN #2 SPARE	FAN #4 SPARE	FAN #6 SPARE			
POINT #5	DTS INDICATION: "EXHAUST"	FAN #1 MOTOR STARTER COIL- SUPPLY	FAN #3 MOTOR STARTER COIL- SUPPLY	FAN #5 MOTOR STARTER COIL- SUPPLY	FAN #7 MOTOR STARTER COIL- SUPPLY	LOCAL STROBE LIGHT (PRE FAN START WARNING)		
POINT #6		FAN #1 MOTOR STARTER COIL- EXHAUST	FAN #3 MOTOR STARTER COIL- EXHAUST	FAN #5 MOTOR STARTER COIL- EXHAUST	FAN #7 MOTOR STARTER COIL- EXHAUST	LOCAL AUDIBLE BUZZER (PRE FAN START WARNING)		
POINT #7		FAN #1 DISCHARGE AIR DAMPER AIR VALVE/RELAY	FAN #3 DISCHARGE AIR DAMPER AIR VALVE/RELAY	FAN #5 DISCHARGE AIR DAMPER AIR VALVE/RELAY	FAN #7 DISCHARGE AIR DAMPER AIR VALVE/RELAY	WIRED SPARE W/ FILTERED 120VAC POWER		
POINT #8		FAN #1 SPARE	FAN #3 SPARE	FAN #5 SPARE	FAN #7 SPARE			
POINT #9	DTS ALARM: "REMOTE CONTROL ABNORMAL"							
POINT #10	DTS ALARM: "OPERATION ABNORMAL"							
POINT #11	DTS ALARM: "FAN SHAFT DAMPER ABNORMAL"							
POINT #12	DTS ALARM: "HIGH TUNNEL TEMPERATURE"							
POINT #13	DTS ALARM: "LOW TUNNEL TEMPERATURE"							
POINT #14								
POINT #15								
POINT #16								

50/100 PLC I/O POINTS TABLE

SCALE: N.T.S.

"PROFESSIONAL CERTIFICATION: I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND."

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REFERENCE DRAWINGS

NUMBER	TITLE

REVISIONS

DATE	NUM	DESCRIPTION
1/15/2016	1	100% DESIGN

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

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CENI - POWER SYSTEMS ENGINEERING

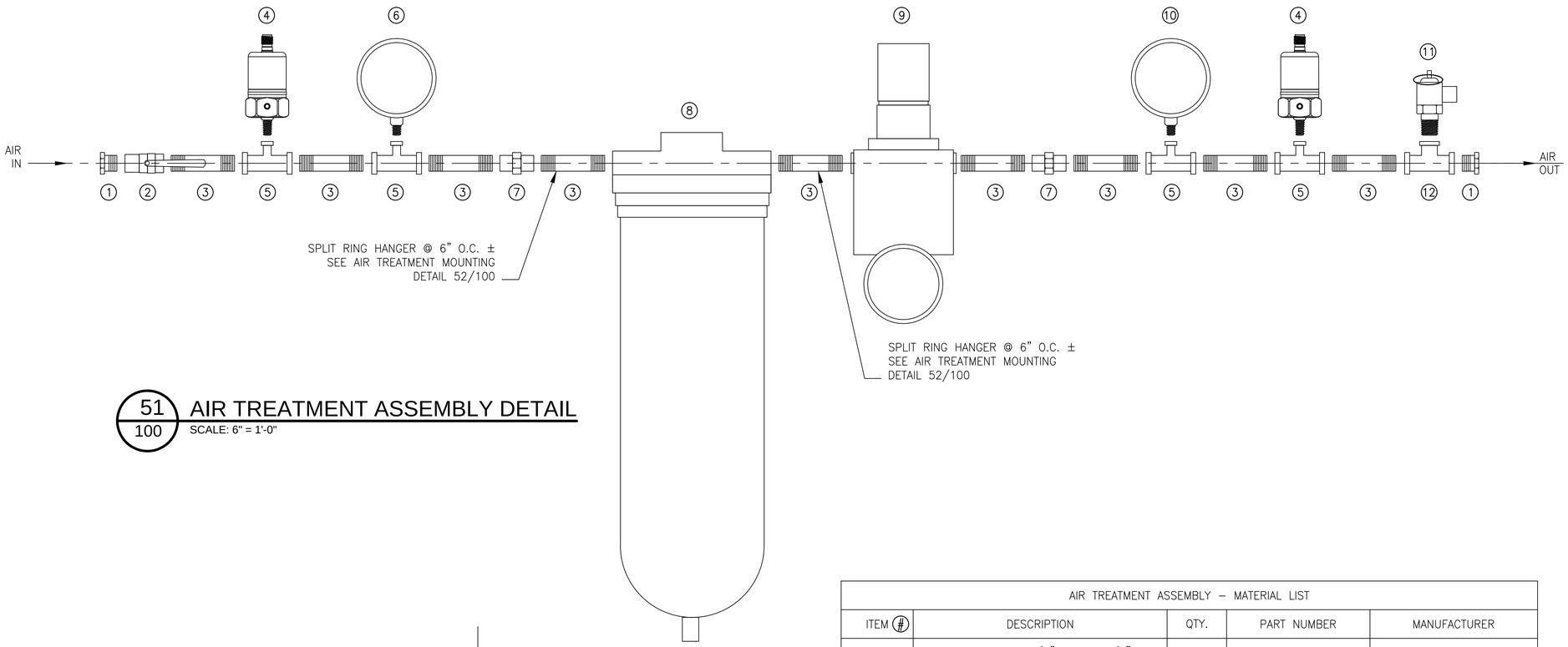
DATE

APPROVED
ASHTON ROBINSON
DEPUTY CHIEF ENGINEER
DATE

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-101	39 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\PLC PANEL LAYOUT\CAD\ST-ME-FAN-100 IO POINTS TABLE.DWG
Plotted by: E011967 Date: Thu, 24 Mar 2016 Time: 04:17:57 pm
Xrefs:
Images:

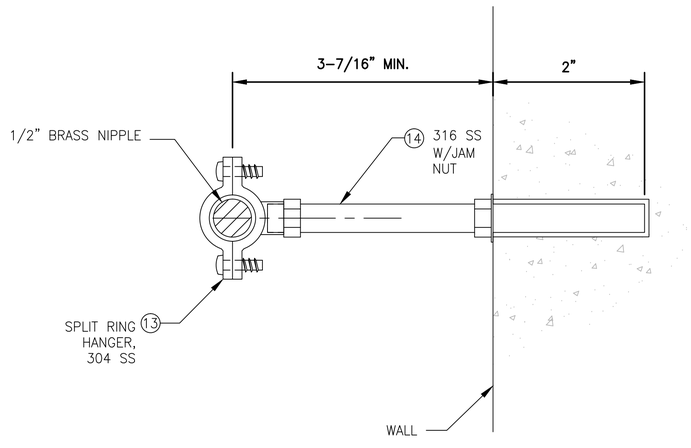


51/100 AIR TREATMENT ASSEMBLY DETAIL

SCALE: 6" = 1'-0"

GENERAL NOTES:

1. ALL (#) REFER TO ITEMS IN THE AIR TREATMENT ASSEMBLY– MATERIAL LIST ON THIS DRAWING SHEET.



52/100 AIR TREATMENT ASSEMBLY MOUNTING DETAIL

SCALE: 1-0" = 1'-0"

AIR TREATMENT ASSEMBLY – MATERIAL LIST				
ITEM (#)	DESCRIPTION	QTY.	PART NUMBER	MANUFACTURER
1	REDUCING BUSHING 1/2" NPT – 3/8" NPT	2	2725K55	MCMASTER–CARR
2	1/2" X 1/2" BALL VALVE–FULL PORT	1	63769491	MSC
3	1/2" NPT X 2" BRASS NIPPLE	9	4568K173	MCMASTER–CARR
4	PRESSURE TRANSDUCER, 0–100PSI,4–20MA	2	PTD25–20–0100H	AUTOMATION DIRECT
5	1/2" X 1/2" X 1/4" NPT REDUCING TEE	4	4429K226	MCMASTER–CARR
6	0–100 PSI PRESSURE GAUGE	1	56452279	MSC
7	1/2" NPT UNION	3	4429K214	MCMASTER–CARR
8	AIR DRYER	1	79895066	MSC
9	PRESSURE REGULATOR	1	04290672	MSC
10	0–30 PSI PRESSURE GAUGE	1	56452253	MSC
11	1/2" NPT RELIEF VALVE 30 PSI	1	37012523	MSC
12	1/2" X 1/2" X 1/2" NPT TEE	1	4429K253	MCMASTER–CARR
13	SPLIT RING HANGER	2	02162725	MSC
14	3/8" ø X 5" CONCRETE ANCHOR, 316 SS	2	97799A203	MCMASTER–CARR

"PROFESSIONAL CERTIFICATION: I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND."

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CENI - POWER SYSTEMS ENGINEERING

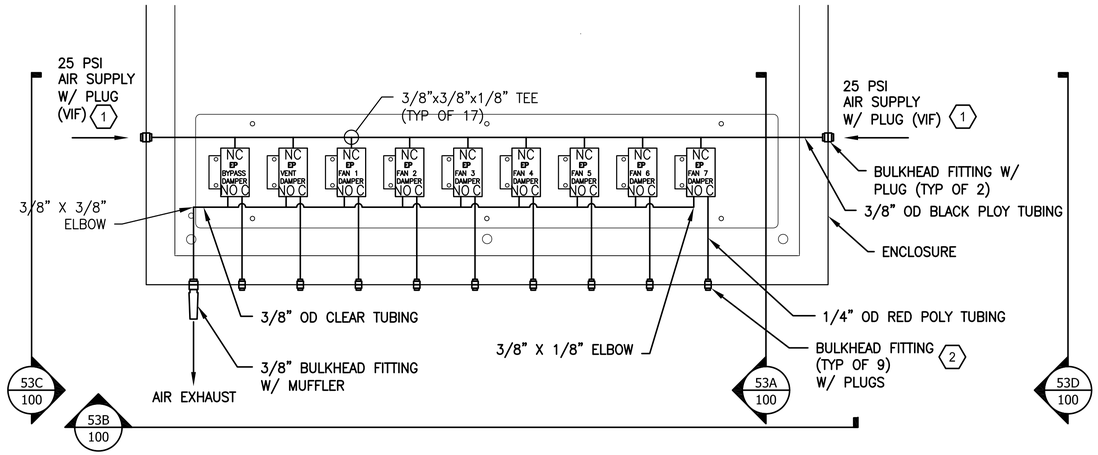
REVISION SUBMITTED _____ DATE

APPROVED _____ DATE
ASHTON ROBINSON
DEPUTY CHIEF ENGINEER

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

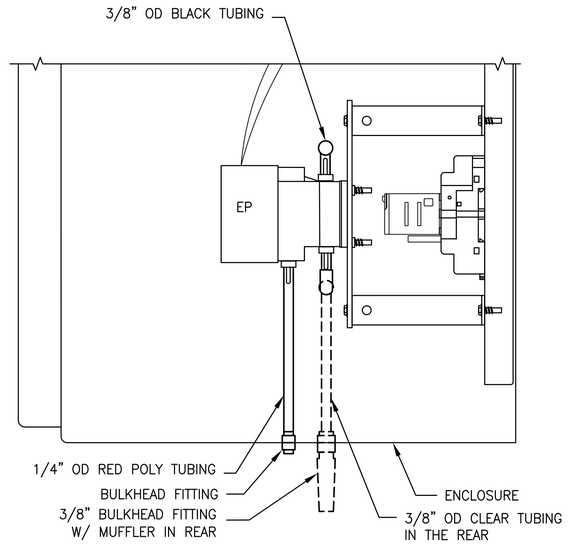
CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	40 of 42

Drawing File: N:\ROBINSON-ELECT-MECH\MECH\PLC PANEL LAYOUT\CAD\ST-ME-FAN-100 AIR TREATMENT DETAIL.DWG
Plotted by: E011967 Date: Thu, 24 Mar 2016 Time: 04:18:02 pm
Xrefs:
Images: ; MARYLAND_ARCHITECT.jpg ; MARYLAND_ENGINEER.jpg ; Virginia_Architect.jpg ; Virginia_Engineer.jpg ; N:\R



53/100 PNEUMATIC CONNECTION DETAIL

SCALE: 3" = 1'-0"



53A/100 SECTION

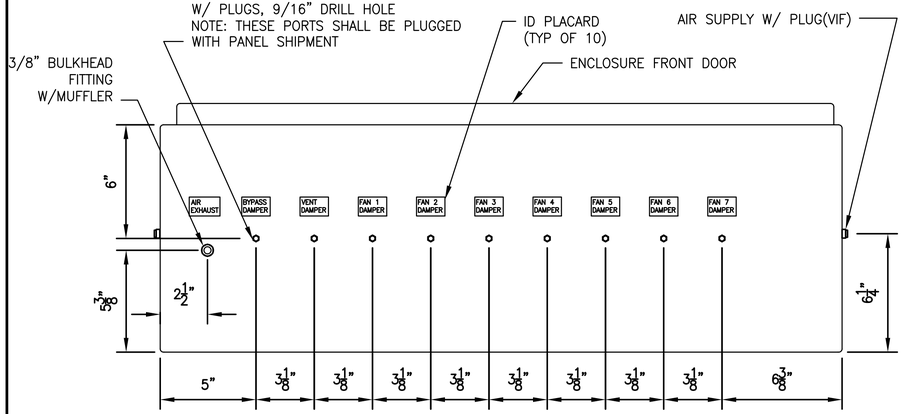
SCALE: 6" = 1'-0"

GENERAL NOTES:

1. ALL PNEUMATIC TUBING WITHIN THE CONTROL PANEL SHALL BE OF NYLON OR POLYURETHANE TYPE WITH PUSH TO CONNECT FITTINGS USED.
2. BULK HEAD FITTINGS SHALL BE USED AT ALL PANEL PENETRATIONS. THE BULKHEAD FITTINGS SHALL HAVE FEMALE NPT EXTERNAL PORTS.
3. ALL PNEUMATIC TUBING EXTERNAL OF CONTROL PANEL SHALL BE WITHER COPPER OR BRASS. NO POLY TUBING IS ALLOWED EXTERNAL OF CONTROL PANEL.
4. ALL BULKHEAD FITTINGS SHALL RECEIVE AN ADHESIVE BACK LABEL ADJACENT TO EACH FITTING ON THE ENCLOSURE EXTERIOR. THE SUBSTRATE SHALL BE CLEANED WITH ALCOHOL PRIOR TO ATTACHING THE LABELS.
5. THE PNEUMATIC TUBING SHALL BE COLOR CODED AS DRAWING SHOWN TO AID OPERATION & MAINTENANCE PERSONNEL.
6. PROPER THREAD SEALANT SHALL BE USED ON ALL NON-PLASTIC THREADED FITTINGS.

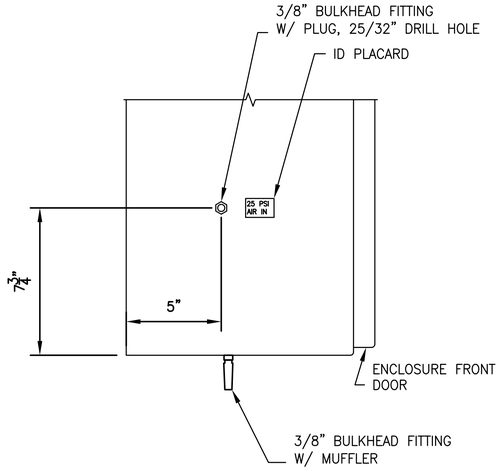
(#) NOTES:

1. THE CONTROL PANEL HAS TWO LOCATIONS FOR 25 PSI REGULATED AIR TO ACCOMMODATE DIFFERENT SITE NEEDS WHEN INSTALL. BOTH LOCATIONS SHALL RECEIVE BRASS PLUGS WHEN THE CONTROL PANEL IS BUILT. AT TIME OF INSTALLATION, THE ONE PORT NOT USED SHALL REMAIN SEALED.
2. PLASTIC PIPE PLUGS SHALL BE FACTORY INSTALLED AT ALL BULKHEAD FITTINGS TO AVOID THE INGRESS OF DIRT PRIOR TO INSTALLATION.



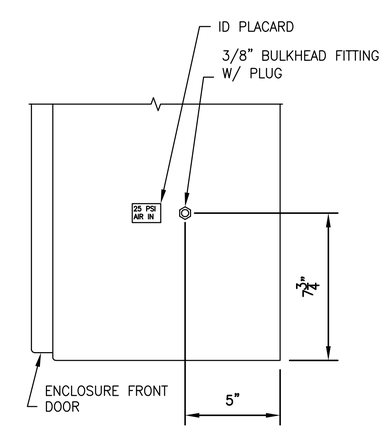
53B/100 SECTION

SCALE: 3" = 1'-0"



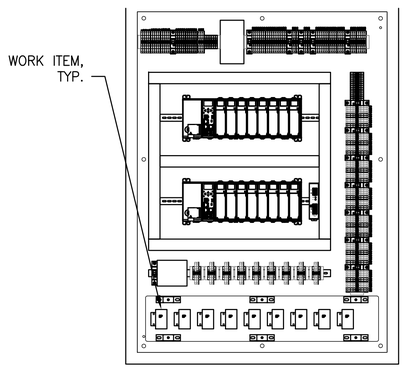
53C/100 SECTION

SCALE: 3" = 1'-0"



53D/100 SECTION

SCALE: 3" = 1'-0"



KEY PLAN

"PROFESSIONAL CERTIFICATION: I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND."

LICENSE No. _____.

EXPIRATION DATE: _____

- COMAR 09.23.03.10

DESIGNED	C. Lesefske	9-4-2015 DATE
DRAWN	Y. Liu	9-16-2015 DATE
CHECKED	P. Petersen	9-24-2015 DATE

REFERENCE DRAWINGS

NUMBER	TITLE

REVISIONS

DATE	NUM	DESCRIPTION
1/15/2016	1	100% DESIGN

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

DEPARTMENT OF TRANSIT INFRASTRUCTURE AND ENGINEERING SERVICES
CENI - POWER SYSTEMS ENGINEERING

DATE

APPROVED
ASHTON ROBINSON
DEPUTY CHIEF ENGINEER
DATE

MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	41 of 42

MATERIAL LIST – PNEUMATIC CONNECTION

ITEM	DESCRIPTION	QTY	PART NO.	MANUFACTURER
1	FITTING MALE BRANCH TEE, ROT–PBT (2) 3/8 IN TUBE TO 1/8 IN MNPT	17	MBT38–18N	AUTOMATION DIRECT
2	FITTING LONG MALE ELBOW, ROT–PBT 3/8 IN TUBE TO 1/8 IN MNPT	1	MEL38–18N	AUTOMATION DIRECT
3	FITTING MALE STR, BRASS 1/4 IN TUBE TO 1/8 IN MNPT	9	MS14–18N	AUTOMATION DIRECT
4	FTG BULKHEAD FEMALE, BRASS 1/4 IN TUBE TO 1/4 IN FNPT	9	FB14–14N	AUTOMATION DIRECT
5	FTG BULKHEAD FEMALE, BRASS 3/8in TUBE TO 3/8in FNPT	3	FB38–38N	AUTOMATION DIRECT
6	FITTING UNION ELBOW, PBT (2) 3/8 IN TUBE	1	UL38	AUTOMATION DIRECT
7	1/4" PIPE PLUG, BRASS, NPT THREAD, HEX HEAD TYPE	9	50785K253	MCMASTER
8	3/8" PIPE PLUG, BRASS, NPT THREAD, HEX HEAD TYPE	3	50785K254	MCMASTER
9	PNEUMATIC TUBING, POLYURETHANE, 1/4 IN OD, 0.156 IN ID, RED, 100 FT PKG	1	PU14RED100	AUTOMATION DIRECT
10	PNEUMATIC TUBING, POLYURETHANE, 3/8 IN OD, 0.250 IN ID, BLACK, 100 FT PKG	1	PU38BLK100	AUTOMATION DIRECT
11	PNEUMATIC TUBING, POLYURETHANE, 3/8 IN OD, 0.250 IN ID, CLEAR, 100 FT PKG	1	PU38CLR100	AUTOMATION DIRECT

"PROFESSIONAL CERTIFICATION: I HEREBY CERTIFY THAT THESE DOCUMENTS WERE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND."

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MECHANICAL DESIGN DRAWING
FAN SYSTEM
TUNNEL VENTILATION CONTROL SYSTEM
PLC CONTROL AND SEQUENCE OF OPERATION

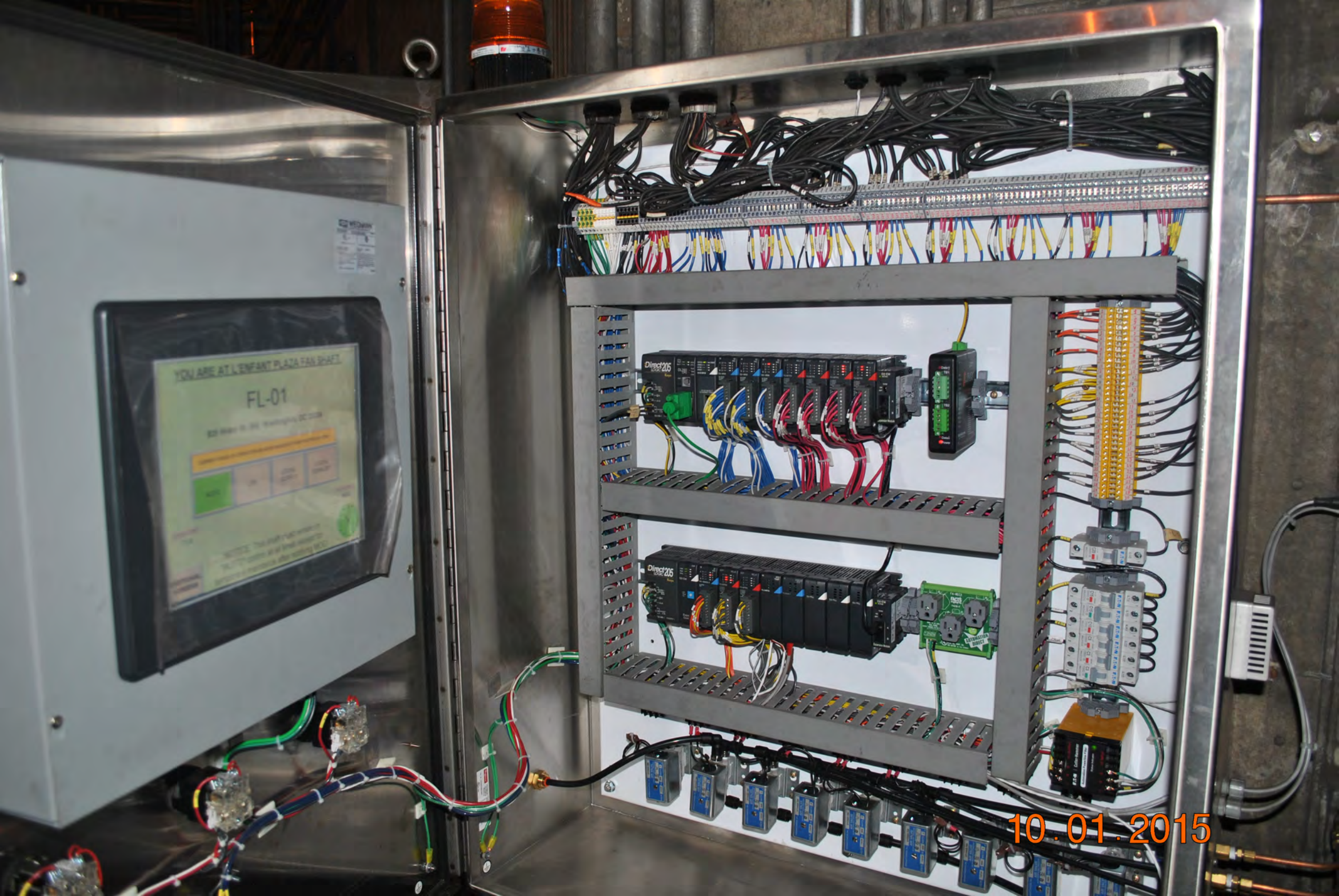
CONTRACT NO.	SCALE	DRAWING NO.	SHEET NO.
FQ-	AS NOTED	ST-ME-FAN-100	42 of 42

Drawing File: N:\ROBINSON–ELECT–MECH\MECH\PLC PANEL LAYOUT\CAD\ST–ME–FAN–100 PNEUMATIC TUBING CONNECTION.DWG
Plotted by: E011967 Date: Fri, 25 Mar 2016 Time: 01:58:55 pm
Xrefs: ; ; \FAN PLC PANEL.dwg
Images: ; ; DC_Architect.jpg ; DC_Engineer.jpg ; MARYLAND_ARCHITECT.jpg ; MARYLAND_ENGINEER.jpg ; Virginia_Architect.jpg ; Virginia_Engineer.jpg ; N:\ROBINSON–ELECT–MECH\MECH\CAD Standard\DWG BLOCKS\Bord


10.01.2015


10.01.2015


REMOTE CONTROL
OMEGA
NORGREN
10.01.2015


YOU ARE AT L'ENFANT PLAZA FAN SHAFT
FL-01
10.01.2015